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ART. XV.—*Memoir on Meteorites—A Description of five new Meteoric Irons, with some theoretical considerations on the origin of Meteorites based on their Physical and Chemical characters;* by J. LAWRENCE SMITH, M.D., Professor of Chemistry in the Medical Department of the University of Louisville.

(Read before the American Association for the Advancement of Science, April, 1854.)

1. *Meteoric Iron from Tazewell County, East Tennessee.**

THIS meteorite was placed in my possession through the kindness of Prof. J. B. Mitchell of Knoxville, in the month of August, 1853. It was found by a son of Mr. Rogers living in that neighborhood, while engaged in ploughing a hill-side; his attention was drawn to it by its sonorous character. As it very often happens among the less informed, it was supposed to be silver or to contain a large portion of that metal. With some difficulty the mass was procured by Prof. Mitchell, and passed over to me. Nothing could be ascertained as to the time of its fall; it is stated among the people living near where the meteorite was found, that a light has been often seen to emanate from and rest upon the hill, a belief that may have had its foundation in the observed fall of this body.

The weight of this meteorite was fifty-five pounds. It is of a flattened shape, with numerous conchoidal indentations, and three annular openings passing through the thickness of the mass near

* Notice of the discovery of this iron was given by me in 1853.—J. L. S.

the outer edge. Two or three places on the surface are flattened, as if other portions were attached at one time, but had been rusted off by a process of oxydation that has made several fissures in the mass so as to allow portions to be detached by the hammer, although when the metal is sound the smallest fragment could not be thus detached, it being both hard and tough. Its dimensions are such that it will just lie in a box 13 inches long, 11 inches broad and $5\frac{1}{2}$ inches deep. The accompanying figure gives a correct idea of the appearance of this meteorite.

1.

The exterior is covered with oxyd of iron, in some places so thin as hardly to conceal the iron, in other places a quarter of an inch deep. Its hardness is so great that it is almost impossible to detach portions by means of a saw. Its color is white, owing to the large amount of nickel present; and a polished surface when acted on by hot nitric acid displays in a most beautifully regular manner the Widmannstättian figures. The specific gravity taken on three fragments selected for their compactness and purity, is from 7·88 to 7·91.

The following minerals have been found to constitute this meteorite: 1st. *Nickeliferous iron*, forming nearly the entire mass. 2nd. *Protosulphuret of iron*, found in no inconsiderable quantity on several parts of the exterior of the mass. 3d. *Schreibersite*, found more or less mixed with the pyrites and in the crevices of the iron, in pieces from the thickness of the blade of a penknife to that of the minutest particles. 4th. *Olivine;* two or three very small pieces of this mineral have been found in the interior of the iron. 5th. *Protochlorid of iron;* this mineral has been found in this meteorite *in the solid state*, which I believe is the first observation of this fact; it was found in a crevice

that had been opened by a sledge hammer, and in the same crevice Schreibersite was found. Chlorid of iron is also found deliquescing on the surface; some portions of the surface are entirely free from it, while others again are covered with an abundance of rust arising from its decomposition.

Besides the above minerals two others were found, one a siliceous mineral, the other in minute rounded black particles; both, however were in too small quantity for any thing like a correct idea to be formed of their composition.

The different minerals that admitted of it, were examined chemically, and the following are the results:

1. *Nickeliferous Iron.*—The specific gravity of this iron is as already stated, from 7·88 to 7·91. It is not readily acted on by any of the acids in the cold; nitric acid, either concentrated or dilute, has no action on it until heated to nearly 200° Fahr., when the action commences, and continues with great vigor even after the withdrawal of heat. With reference to the action of sulphate of copper, it is *passive*, although when immersed in a solution of sulphate of copper and allowed to remain for several hours the latter metal deposits itself in spots on the surface of the iron.

Thorough digestion in hot nitric acid dissolves the iron completely. When boiled with hydrochloric acid the iron dissolves with the liberation of hydrogen, leaving undissolved the Schreibersite; but by long continued action this latter is also dissolved with the evolution of phosphuretted hydrogen.

The following ingredients were detected on analysis of two specimens:

	1.	2.
Iron,	82·39	83·02
Nickel,	15·02	14·62
Cobalt,	·43	·50
Copper,	·09	·06
Phosphorus,	·16	·19
Chlorine,		·02
Sulphur,		·08
Silica,	·46	·84
Magnesia,		·24
	98·55	99·57

Tin and arsenic were looked for, but neither of those substances detected. The magnesia and silica are doubtless combined, probably in the form of olivine, and disseminated in minute particles through the iron. The phosphorus is in combination with a given portion of iron and nickel, forming Schreibersite; the 16 per cent. of phosphorus corresponds to 1·15 of Schreibersite: so the metal mass may be looked on as composed of

Nickeliferous iron 98·97, Schreibersite 1·03=100·00.

The composition of the nickeliferous iron corresponds to five atoms of iron and 1 of nickel.

Iron,	5 atoms,	82·59
Nickel,	1 "	17·41=100·00

2. *Protosulphuret of Iron.*—This variety of sulphuret of iron found with meteorites is usually designated as magnetic pyrites, leaving it to be inferred that its composition is the same as the terrestrial variety. Without alluding to the doubt among some mineralogists as to the true composition of the terrestrial magnetic pyrites, I have only to say that most careful examination of the sulphuret detached from the meteorite in question proves it to be a protosulphuret; a conclusion to which Rammelsberg had already come, with reference to the pyrites of the Seelasgen iron, which latter pyrites I have also examined, confirming the results of Rammelsberg.

This pyrites encrusts some portion of the iron, and in places is mixed with a little Schreibersite. It presents no distinct crystalline structure, has a grey metallic lustre, and a specific gravity of 4·75. The Seelasgen pyrites gave me for specific gravity 4·681.

The specimen of pyrites in question gave, on analysis:

Iron 62·38, sulphur 35·67, nickel 0·32, copper *trace*, silica 0·56, lime 0·08=98·91.

The formula Fe S requires sulphur 36·36, iron 63·64.

The magnetic property of this mineral is far inferior to that possessed by Schreibersite.

3. *Schreibersite.*—It is found disseminated in small particles through the mass of the iron, and is made evident by the action of hydrochloric acid; it is also found in flakes of little size, inserted as it were into the iron, and owing to the fact that in many parts where it occurs chlorid of iron also exists, this last has caused the iron to rust in crevices, and on opening these, Schreibersite was detached mechanically. This mineral as it exists in the meteorite in question, so closely resembles magnetic pyrites that it can be readily mistaken for this latter substance, and I feel confident in asserting that a great deal of the so-called magnetic pyrites associated with various masses of meteoric iron, will upon examination, be found not to contain a trace of sulphur, and will on the contrary prove to be Schreibersite that can be easily recognised by the characters to be fully detailed a little farther on.

Its color is yellow or yellowish white, sometimes with a greenish tinge; lustre metallic; hardness 6; specific gravity 7·017. No regular crystalline form was detected; its fracture in one direction is conchoidal. It is attracted very readily by the magnet, even more so than magnetic oxyd of iron; it acquires polarity and retains it. I have a piece $\frac{3}{10}$ of an inch long, $\frac{2}{10}$ of an inch broad, and $\frac{1}{20}$ of an inch thick, which has retained its polarity over six months; unfortunately the polarity was not tested immediately when it was detached from the iron, and not until it had come in contact with a magnet, so that it cannot be pronounced as originally polar.

Before the blowpipe it melts readily, little blisters forming on the surface from the escape of *chlorine*, and blackens. The magnet is a most ready means of distinguishing the Schreibersite from the pyrites commonly found in meteoric irons, for although the pyrites is attracted by the magnet, it is necessary that the latter should be brought quite near to it for the effect to be produced, whereas if the particles exposed to the magnet be Schreibersite, they will be attracted with almost the readiness of iron filings.

Hydrochloric acid acts exceedingly slowly on this mineral when pulverized, with the formation of phosphuretted hydrogen. Nitric acid acts more vigorously and readily dissolves it when finely pulverized. The composition of this substance has in all cases but one, been made out from the residue of meteoric iron, after having been acted on by hydrochloric acid, which accounts for the great variation in the statements of the proportion of its constituents.

Mr. Fisher examined pieces of Schreibersite detached from the Braunau iron, with the following results: Iron 55·430, nickel 25·015, phosphorus 11·722, chrome 2·850, carbon 1·156, silex 0·985 = 98·158.

The results of my analyses do not differ very materially from this; they are as follows:

	1.	2.	3.
Iron,	57·22	56·04	56·53
Nickel,	25·82	26·43	28·02
Cobalt,	0·32	0·41	0·28
Copper,	*trace*	not estimated.	
Phosphorus,	13·92		14·86
Silica,	1·62		
Alumina,	1·63		
Zinc,	*trace*	not estimated.	
Chlorine,	0·13		
	100·66		99·69

Nos. 1 and 2 were separated mechanically from the iron. No. 3 chemically. The silica, alumina and lime were almost entirely absent from No. 3, and in the other specimen they are due to a siliceous mineral that I have found attached in small particles to the Schreibersite. There is no essential difference in my results, yet in neither instance do I suppose the mineral was obtained perfectly pure; although enough so, it is believed, to furnish the correct chemical formula; and, as from what has been previously said, Schreibersite will be found to exist in larger quantities than it was suspected, it will not be long before the question of the uniformity of its composition will be settled, a point of interest bearing upon the theoretical consideration of meteoric stones.

The formula of Schreibersite, I consider to be Ni_2Fe_4P.

		Per cent.
Phosphorus,	1 atom	15·47
Nickel,	2 "	29·17
Iron,	4 "	55·36

This mineral although not usually much dwelt upon when speaking of meteorites, is decidedly the most interesting one associated with this class of bodies, even more so than the nickeliferous iron. It has no representative in genus or species among terrestrial minerals, and is one possessed of highly interesting properties. Although among terrestrial minerals phosphates are found, not a single phosphuret is known to exist; so true is this (that with our present knowledge) if any one thing could convince me more strongly than another of the non-terrestrial origin of any natural body, it would be the presence of this or some similar phosphuret. It is commonly alluded to as a residue from the action of hydrochloric acid upon meteoric iron, when in fact it exists in plates and fragments of some size in almost all meteoric iron; and there is reason to believe that it is never absent from any of them in some form or other: what is meant by "some size" is, that it is in pieces large enough to be seen by the naked eye, and to be detached mechanically.

In an examination of the meteoric specimens in the Yale College Cabinet, more than half of them have been discovered to contain Schreibersite visible to the eye, that had been considered pyrites. Among them, the large Texas meteorite was examined, and although none was visible on the surface, a small fragment of the same mass given me by Prof. Silliman, contains a piece of Schreibersite of over a grain weight.

The reason why it has not attracted more attention, arises from its resemblance to pyrites; I will therefore state a ready manner of telling whether it be such or not.

Detach a small fragment, and hold a magnet capable of sustaining five or six ounces or more, within half an inch or an inch of the fragment, if it be Schreibersite it will be attracted with great readiness; the magnetic pyrites requiring a very close approximation of the magnet before attracted. This, with some little experience, becomes a ready method of separating the two. It is not, however, to be expected that this method alone, is to satisfy us, when other means can be appealed to for distinguishing this mineral; the following is one which is readily accomplished with the smallest fragment (half a milligramme). Melt in a small loop of platinum wire, a little carbonate of soda, add the smallest fragment of nitrate of soda and the piece of mineral, hold the mixture in the flame of a lamp for two or three minutes; place the bead of soda in a watch glass, add a little water and filter; to the filtrate add a drop or two of acid to neutralize the excess of carbonate of soda; evaporate nearly to dryness; add a drop of ammonia, and then a drop of ammoniacal sulphate of magnesia, when the double phosphate of magnesia and ammonia will show itself, and the crystalline form will be recognised under the microscope. If the piece examined be several milligrammes in weight,

the operation can be carried on in a small platinum capsule. This reaction can also be had by acting on the mineral, however small the piece, by aqua-regia, evaporate until only a little of the liquid is left, add a little tartaric acid, then a drop or two of ammonia to supersaturate the acid, and lastly a little ammoniacal sulphate of magnesia, when the crystals of the double phosphate of magnesia and ammonia will appear.

4. *Protochlorid of Iron.*—In breaking open one of the fissures of this meteoric iron, a small amount of a green substance was obtained, that was easily soluble in water, and although not analyzed quantitatively, it left no doubt upon my mind as to its being protochlorid of iron; and the manner of its occurrence gave strong evidence of its being an original constituent of the mass, and not formed since the fall of the mass. Chlorid of iron was apparent on various parts of the iron by its deliquescence on the surface.

2. *Meteoric Iron from Campbell County, Tenn.*

This meteorite was discovered in July, 1853, in Campbell County, Tennessee, in Stinking Creek, which flows down one of the narrow valleys of the Cumberland mountains. It was found by a Mr. Arnold in the channel of this stream, and having been obtained by Prof. Mitchell of Knoxville, he kindly presented it to me. It is a small oval mass 2¼ inches long, 1¾ broad, and ¾ thick, with an irregular surface and several cavities perforating the mass. It was covered with a thin coat of oxyd; and on one half of it chlorid of iron was deliquescing from the surface, while on another portion there was a thin siliceous coating.

The iron composing the mass was quite tough, highly crystalline, and exhibited small cavities on being broken, resembling very much in this respect, as well as in many other points, the Hommony Creek iron; a polished surface when etched, exhibited distinct irregular Widmannstättian figures.

The weight is 4¼ ounces. Specific gravity, 7·05. The lowness of the specific gravity is accounted for by its porous nature. Composition—

Iron,	97·54
Nickel,	0·25
Cobalt,	0·6
Copper, too small to be estimated.	
Carbon,	1·50
Phosphorus,	0·12
Silica,	1·05
	100·52

Chlorine exists in some parts in minute proportion. The amount of nickel, it will be seen is quite small, but its composition is nevertheless perfectly characteristic of its origin.

3. *Meteoric Iron from Coahuila, Mexico.*

This meteorite was brought to this country by Lieut. Gouch, of the U. S. Army, he having obtained it at Saltillo. It was said to have come from the Sancha estate, some fifty or sixty miles from Santa Rosa in the north of Coahuila; various accounts were given of the precise locality, but none seemed very satisfactory. When first seen by Lieut. Gouch, it was used as an anvil, and had been originally intended for the Society of Geography and Statistics in the city of Mexico. It is stated that where this mass was found, there are many others of enormous size; these stones, however, it is well known, are to be received with many allowances. Mr. Weidner, of the mines of Freiberg, states that near the southwestern edge of the Balson de Mapimi, on the route to the mines of Parral, there is a meteorite near the road of not less than a ton weight. Lieut. Gouch also states that the intelligent but almost unknown Dr. Berlandier, writes in his journal of the commission of limits, that at the Hacienda of Venagas there was (1827) a piece of iron that would make a cylinder one yard in length with a diameter of ten inches. It was said to have been brought from the mountains near the Hacienda. It presented no crystalline structure, and was quite ductile.

The meteoric mass in question, which is at the Smithsonian Institution, is of the form represented in the figure, and one well

2.

adapted for an anvil. Its weight is 252 lbs., and from several flattened places, I am led to suppose that pieces have become detached. The surface, although irregular in some places, is rather smooth, with only here and there thin coatings of rust, and, as might be expected, but very feeble evidence of chlorine, and that only on one or two spots on the surface. Specific gravity 7·81. It is highly crystalline, quite malleable, and not difficult to cut with the saw. Its surface etched with nitric acid, presents the Widmannstättian figures, with a finely specked surface between

the lines, resembling the representation we have of the etched surface of Hauptmannsdorf iron. Schreibersite is visible in the iron, but so inserted in the mass, that it cannot be readily detected by mechanical means. Hydrochloric acid leaves a residue of beautifully brilliant patches of this mineral.

Subjected to analysis, it was found to contain

		Which corresponds to	
Iron,	95·82	Nickeliferous Iron,	98·45
Cobalt,	·35	Schreibersite,	1·55
Nickel,	3·18		100·00
Copper, minute quantity not estimated.			
Phosphorus,	0·24		
	99·59		

The iron is remarkably free from other constituents. It is especially interesting as the largest mass of meteoric iron in this country next to the Texas meteorite at Yale College.

4. *Meteoric Iron from Tucson, Mexico.*

We have had several accounts of meteoric masses which exist at Tucson; Dr. J. L. LeConte having made them known some few years ago. Since that time Mr. Bartlett, of the Boundary Commission, has seen them and made a drawing of one which he has kindly allowed me the use of, as well as the manuscript* notice of them, which is however, quite brief. This mass is used for an anvil, resembles native iron, and weighs about six hundred pounds. Its greatest length is five feet. Its exterior is quite smooth, while the lower part which projects from the larger leg is very jagged and rough. It was found about twenty miles distant towards Tubac, and about eight miles from the road where we are told are many larger masses. The following figure (3) represents the appearance of that meteorite.

Since my communication last April, I have obtained fragments of the meteorite from Lieut. Jno. G. Parke, of the U. S. Topographical Engineers, who cut them from the mass at Tucson, and to whose kindness I feel much indebted.

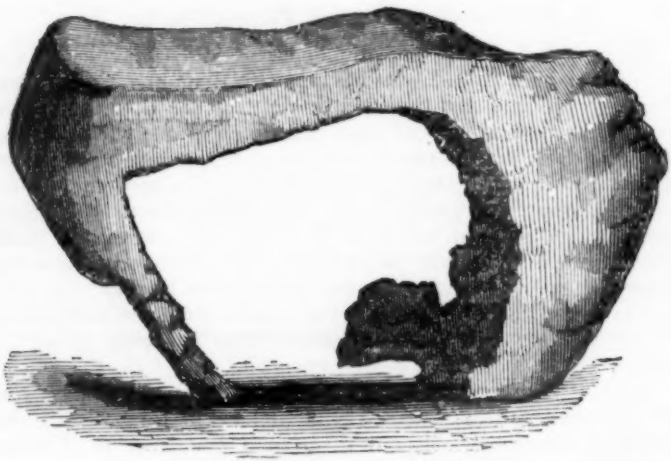
Some of the fragments were entirely covered with rust, and in some parts, little blisters existed, arising from chlorid of iron. Portions of the broken surface retain their metallic lustre untarnished. The Widmannstättian figures are very imperfectly developed, owing to the porous nature of the iron, the pores of which are filled with a stony mineral. The specific gravity taken on three specimens were 6·52—6·91—7·13. The last was the most compact and free from stony particles that could be found, and upon that the chemical examination was made.

* Since this was communicated to the American Association for the Advancement of Science, Mr. Bartlett's valuable and instructive work, entitled "Personal Narrative of Explorations in Texas, New Mexico, California, Sonora, and Chihuahua," has been published in two handsome octavo volumes, by the Messrs. Appleton's, New York: and we are indebted to the publishers for the use of Mr. Bartlett's fine cuts on the following pages.—J. L. S.

On examination it is seen to consist of two distinct parts, metallic and stony; the latter was only in minute particles, yet it was impossible, among the specimens at my disposal, to find a piece that was without it. On analysis, the following ingredients were found:

		Which represent the following minerals:	
Iron,	85·54		
Nickel,	8·55		
Cobalt,	·61	Nickeliferous iron,	93·81
Copper,	·03	Chrome iron,	·41
Phosphorus,	·12	Schreibersite,	·84
Chromic oxyd,	·21	Olivine,	5·06
Magnesia,	2·04		100·12
Silica,	3·02		
Alumina.	*trace*		
	100·12		

3.



Some few particles of olivine were separated mechanically, and readily recognised as such under the magnifying glass in connection with the action of acids, which readily decompose it, furnishing silica and magnesia. Some of the olivine is in a pulverulent condition, resembling that of the Atacama iron. The nickeliferous iron of this Tucson meteorite also resembles that of the Atacama iron; calculated from the above results, it consists of

Iron 90·91, nickel 8·46, cobalt 63, copper, *trace*=100·00.

This meteorite* is one of much interest, and it is to be hoped that some of our enterprising U. S. Topographical Engineers

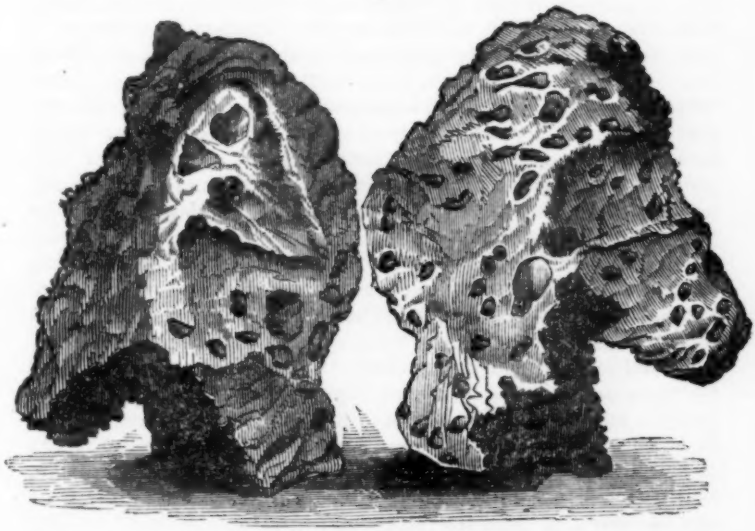
* Since my notice of this meteorite, Prof. C. U. Shepard has published (Am. Journal of Science, Nov. 1854) an account of it, not aware of my communication to the Am. Assoc. He seems inclined to think that the stony material might be chladnite, although he could form no definite conclusion on this head. From what has

will yet be able to persuade the owners to part with it and bring it to this country.

5. *Meteoric Iron of Chihuahua, Mexico.*

For the description of this meteorite, I am indebted to the manuscript of Mr. Bartlett, and had hoped to have obtained a fragment of it for examination from Dr. Webb, who detached pieces from the mass; but when applied to, they were no longer

4.



in his possession. It exists at the *Hacienda de Conception*, about ten miles from Zapata. "The form is irregular. Its greatest height is forty-six inches; greatest breadth thirty-seven inches; circumference in thickest part eight feet three inches. Its weight as given by Senor Urquida, is about three thousand eight hundred and fifty-three pounds. It is irregular in form, as seen by the figure; and one side is filled with deep cavities, generally round and of various dimensions. At its lower part, as it now stands, is a projecting leg, quite similar to the one on the meteorite at Tucson. The back or broadest part is less jagged than the other portions, and contains fewer cavities, yet, like the rest, is very irregular."

been said in the text, it will be seen to be olivine, the chladnite of the Bishopville stone not being attacked by acid, or only to a very feeble extent, by boiling sulphuric acid. And I would here remark that from some investigations just made, chladnite is likely to prove a pyroxene.—J. L. S.

(*To be continued.*)

ART. XVI.—*On the Periodical Rise and Fall of the Lakes;* by MAJOR LACHLAN, Montreal.

(Continued from p. 71.)

SUCH continued to be the state of the question, till the institution, by the American States, of those great patriotic works, the Geological Surveys of New York, Ohio, and Michigan, when the subject being taken up by the talented individuals employed in that duty, as far as their other immediate avocations would permit, with that spirit which ever distinguishes the lovers of science, I was enabled to glean many interesting additional particulars from their official reports, though, unfortunately, none sufficiently conclusive to solve the great philosophical problem so long under discussion. Among these I, of course rank first the eminent American geologist, Professor Hall, from whose elaborate work, put forth under the enlightened auspices of the State of New York, I extract the following valuable remarks on the elevation and depression of the great Lakes:*

"The fluctuating level of the waters of these Lakes has long excited attention; and many speculations have been hazarded to account for the phenomenon. The somewhat general belief that the periodical rise and fall in their waters occupy seven years appears not to be founded on authentic observation. Sand-bars and beaches, or the inlets of certain bays, are regarded as the landmarks; and these being liable to fluctuation from accumulation and removal, it follows that no hypothesis, founded on such observations, can be of any value. . . It is nevertheless true that there are important fluctuations in the Lake levels, which are unconnected with the temporary influence of winds. The only rational explanation of these changes yet afforded is that depending on the waste and supply of water. From the immense surface exposed to the sun's rays, it is plain that the amount of water evaporated is immense; and if by any means the process becomes retarded, the water is elevated. Again, the greater quantity of snow fallen during certain seasons has been considered a sufficient reason for explaining the increased elevation of the Lakes. If after such a season a summer follows when there is a small degree of sunshine, the amount of evaporation being thus diminished, the Lakes remain at a high point. These causes, though perhaps satisfactory, and without doubt true, at least to a certain extent, do not always appear sufficient to account for the fluctuations which have been noticed. Twenty-five or thirty years ago the beach of Lake Erie was a travelled highway beyond Buffalo; but at this time it would be quite impossible to travel along the same. . . .

* See Hall's Geology of New York, pp. 408 to 410.

"From the united testimony of persons residing along the margins of all the Lakes, and from other demonstrative proofs, it appears that for many years previous to 1838, all the Lakes had been rising, that about that time they attained their maximum, and have since (to 1842) been subsiding. I have no means of determining the time or degree of the minimum depression. Mr. Higgins, the State Topographer of the Geological Survey of Michigan, gives the rise of the Lakes as five feet from 1819 to 1838, and regards it as probable that the minimum period continues for a considerable length of time, while the maximum continues only for a year. . . A single individual has informed me that about 1788 or 1790 the Lakes were nearly as high as in 1838. . . .

"The *annual* fluctuations in the level of the Lakes are doubtless due to the nature of the seasons, depending on the quantity of rain and snow, and the amount of the evaporation; but it is not so satisfactorily demonstrated that for a series of twenty years the quantity of rain and snow has increased, or that evaporation has lessened uniformly throughout that period.

"The effect of winds in producing (*daily*) temporary elevations and depressions is very remarkable. A strong westerly wind will raise the water in the eastern end of Lake Erie several feet in a few hours, when a much larger quantity is driven down the Niagara; and although so rapid a stream below the Falls, the water frequently rises fifteen or twenty feet during a westerly wind. At the same time the water is diminished at the western extremity of the Lake, and a corresponding depression there takes place. The prevalence of a strong easterly or northerly wind in the same way drives the waters to the western and southern parts of the Lake, and a much smaller quantity flows down the Niagara during such period. The same effects take place in a greater or less degree in all the Lakes—the rising at one extremity and the sinking at the other, till the wind subsides, when it resumes the equilibrium, and in so doing presents a beautiful exhibition of the long swells which are observed in the ocean after the subsidence of a high wind."

Professor Hall was well seconded by Professor Mather, afterwards chief director of the Geological Survey of Ohio, and subsequently (in 1845, '46, and '47) a resident on the shores of Lake Superior, observant of the meteorology and change of level of that Lake, from whose reports and other writings I extract the following particulars respecting Lakes Erie and Superior:*

"A tradition exists that there is a periodical rise and fall in Lake Erie, through a certain number of years. If it is true—and there are reasons for believing that it may be so, to a certain extent—

* See Geological Report of Professor Mather for 1838.

it is evident that the present rise (1838) is higher than has occurred for many years before, for extensive tracts of forest are now overflowed, and timber killed in consequence, the trees of which indicate a long period of growth. The causes that may concur to produce such a variation in the level of the Lake are:—1st, An obstruction to the drainage to the usual quantity of water, in consequence of which, if the usual supply continues, the water must rise. 2d, The increased or diminished supply of water, dependent on the wetness or dryness of the season, the relative temperature, and amount of evaporation, both from the surface of the Lake and the country which receives its drainage waters, and the amount of water supplied by the Lakes above, as Lakes Huron, Michigan, and Superior,—the amount of water contributed by which is due to the same general causes, with the possible addition of an increasing water-way from the cutting down of their outlets, and pouring down an additional supply. 3d, Another possible cause may be taken into account in the varying level (or upheaval) of the solid earth itself—examples of which are mentioned in various works on geology, as to be seen in part of the coast of Sweden, where it is said to be slowly rising at the present time."

To this the Professor well adds;—"It is considered an object of great importance to determine what are the *causes* of this effect; and it was therefore intended, if the Legislature had made an appropriation corresponding to the estimate, and with provisions to the Bill which was reported last Session, *to have set in train a series of observations in several localities on the Lake coast*, and in different parts of the States, so that by the period for the close of the survey, a determination of the causes of the rise and fall of the Lake might have been attained. All the aid which the various branches of meteorology could have secured would also have decided the question as to the small *tides*, which are said to be very sensible in some places."

To the foregoing remarks of Professor Mather, I may be permitted to add that it is much to be regretted that any circumstances should have prevented his excellent suggestion from being carried into effect; but that such having unfortunately been the case, it now remains for the *British* province of Canada to have the credit of completing so desirable a work, on a far more extended scale.

Turning again to Lake Superior, I am happy to be able to quote the following (abridged) remarks by the same writer:*

"The great rise and fall of the level of the waters of the great Lakes, through a series of years has been long noticed. The cause is doubtless due to a greater quantity of snow and rain, or

* See Report of Geological Survey of Ohio for 1838–39; and an article in the American Journal of Science for July, 1848.

of a lower mean temperature and diminished evaporation during the period of rise, and the reverse during the time of fall of the water-level. During 1838–39, the waters were higher than they had been before for at least two centuries. This is demonstrated by the large tracts of land that were inundated which were covered with forest trees, many of them the growth of ages. These trees were destroyed by the overflow around Lakes Erie and Huron, and on the Ste. Marie river, between Point Detour and the Sault Ste. Marie.

"We have no accounts of Lake Superior at that time; but there are facts that indicate a marked variation within a few years. In 1845 a rock in the middle of the entrance of Eagle Harbor, showed itself only in the trough of the waves; and the narrow outlet between the west end of Porter's Island and the main land at Copper Harbor, was of such depth that loaded boats could enter without touching the rocks. In 1846, the rock at the mouth of Eagle Harbor was one-and-a half feet above water; and boats could not get into Copper Harbor. In June, 1847, the rock above-mentioned was still more above water, and the outlet to Copper Harbor could be crossed by stepping on the projecting points of the reef, without wetting the feet; and during some depressions of the water by barometrical waves, it was laid almost entirely dry. From the 18th of June to the 6th of September there was a rise of full twelve inches. It has been observed on this lake that the water is lowest in spring and highest in autumn. This is readily explained by the fact that in winter most of the ordinary supplies of water from the drainage of the surrounding country are cut off, by being converted into ice and snow; while evaporation from the surface of the Lake by the dry northern winds continues to carry away a very sensible quantity of water. During the spring, on the contrary, the snow and ice melt, and the accumulated stores of winter flow into the Lake in greater quantity than to compensate for the evaporation and the drainage at the outlet. . . During a century past the waters of Lake Superior cannot have been more than four feet above the level of 1847, for any considerable time, as is evident by the growth of trees of two feet in diameter at Porter's Island, which would have died had the ground around them been inundated for any great length of time.

To descend once more to Lake Erie. I am next indebted to Col. Whittlesey, Topographer to the Geological Survey of Ohio for the following, confined to the annual and daily fluctuations in that Lake, with a variety of other acceptable details respecting particular sudden floods, as well as for a concise but imperfect tabular view of the *reported*, combined with the *known* annual variations in the level of its waters from 1796 to 1838.*

* See Colonel Whittlesey's Report for 1838–39.

"The general belief among navigators and residents on the Lakes appears to be uniform against the existence of any law by which these fluctuations are governed or may be predicted. The scanty information collected tends to the conclusion that these general elevations and depressions are *fortuitous*, and the result of accidental disorder in the seasons throughout the Lake country. It is, however, well established that there *is* in Lake Erie an *annual* tide, independent of the general state* of the water, which rises from eight to fifteen inches in the mean. The minimum occurs about the time of the breaking up of the ice, late in winter. and the maximum late in spring or early in summer and fall. In the winter less change is perceptible; but early in spring it rises very fast, and with great regularity, till it reaches the maximum. All measurements should be taken subject to this change; but I am unable to fix a mean surface for the year, or to give a probable error. . . The geographical position of Lake Erie in reference to the prevailing winds is the cause of irregularities in the *annual* rise and fall of the waters. Its general course being northeast and southwest, discharging at the north, the steady west wind of the fall accelerates the flow of water from this Lake, at the same time retarding its supply from the other lakes.

"It has been asserted that there exists in the Lakes, as in the Ocean, a daily or *lunar* tide. Whether it is true when applied to Huron, Ontario, or other lakes, *is not perhaps entirely settled.* The observations I have been enabled to make on Lake Erie, and the uniform testimony of the waterman and harbor workmen coincide in denying the existence of any change resembling the oceanic tide, and Mr. Davies, the Collector of Customs, writes decidedly: '*This is not the fact;* the examination of the tide-waiter kept at our office, and observations made almost hourly since August last, enable me to assert, without fear of contradiction, that there is no tide upon Lake Erie.'"

It will be perceived that I already happen to possess more accumulated information on the vicissitudes of Lake Erie, to which my own attention and reflections had been more particularly directed, than of all the rest of our great Mediterranean seas put together; and I have now the additional satisfaction of turning to the investigations of my more immediate neighbors, the State Geologists of Michigan, and more especially of their talented chief, the lamented late Dr. Houghton, and his able assistant and topographer, Mr. Higgins.

From the first Report of the former, however, I can only venture to point to the following naked paragraphs, on the change of elevation in the waters of the Lakes, as equally applicable to Canada and to the American States.†

* *Stage* is the word used, meaning "*level*," I presume.—R. L.

† See Geological Report of Michigan for 1839, p. 20 to 22.

"The great interest which this subject possesses, in connection with our Lake Harbors, as well as with those agricultural interests connected with the flat lands bordering the Lakes and Rivers, may be a sufficient apology for introducing the following facts and reflections upon the subject. An accurate and satisfactory determination of the total rise and fall of the waters of the Lakes is a subject, the importance of which, in connection with some of our works of internal improvement and harbors, can at this time scarcely be appreciated.

"Much confusion is conceived to have arisen in the minds of a portion of our citizens, in consequence of a confounding of the regular *annual* rise and fall to which the waters of the Lakes are subject, with that apparently irregular elevation and subsidence which only appears to be completed in a series of years; changes that are conceived to depend upon causes so widely different, that, while the one can be calculated with almost the same certainty as the return of the seasons, the other can by no means be calculated with *any* degree of certainty.

"It is well known to those who have been accustomed to notice the relative height of the water of the Lakes, that during the winter season, while the flow of water from the small streams is either partially or wholly checked by ice, and while the springs fail to discharge their accustomed quantity, the water of the lakes is invariably low. As the spring advances the snow that had fallen during the winter is changed to water, the springs receive their accustomed supply, and the small streams are again opened, their banks being full in proportion to the amount of snow which may have fallen during the winter, added to the rapidity with which it may have been melted. The water of the Lakes, in consequence of this suddenly increased quantity received from the immense number of tributaries, commences rising with the first opening of the spring, and usually attains its greatest elevation—at least in the upper Lakes—sometime in the month of June or July. As the seasons advance, or during the summer and a large portion of the autumnal months, evaporation is increased, and the amount of water discharged by the streams lessened, in consequence of which the water of the Lakes falls very gradually until the winter again sets in, when a still greater depression takes place, from the renewed operations of the causes already mentioned.

"The *extreme variation* in the height of the water from winter to summer is subject to considerable change, according as the winters may vary from cold and dry to warm and wet; but during the past eight years it may be estimated at two feet.

"The annual rise and fall of the waters of the Lakes, dependent, as it manifestly is, upon causes which are somewhat uniform in their operation, must not be confounded with that eleva-

tion and depression to which the waters are subject, independent of causes connected with the seasons of the year. These latter changes, which take place more gradually, sometimes undergoing but little variation for a series of years, are least liable to be noticed, unless they be very considerable; but with respect to *consequences*, they are of vastly more importance, since they are subject to a larger and more permanent range.

"That the waters of the Lakes, from the earliest settlement of the country have been subject to considerable variation in relative height is well known. At one time the belief was very general that these changes took place at regular intervals, rising for a space of seven years, and subsiding for a similar length of time: a belief which would appear to be in consonance with that of the Indians, and with whom, it no doubt originated. It is not wonderful that a subject, the causes of which are so little comprehended by our natives should be invested with an air of mystery, or that an error once propagated, in consequence of the long series of years required to bring about any considerable change could scarcely be eradicated. While the idea of that septennial rise and fall must be regarded as founded in error, it is nevertheless true, that from the earliest records, the height of the Lakes has been subject to a considerable variation, usually rising very gradually and irregularly for a series of years, and after that falling in a similar, but more rapid, manner."

Dr. Houghton concludes a number of other excellent elucidatory remarks by observing, with regard to the succession of previous cold and wet seasons which produced the great *rise* in 1838 —that, "when we take into consideration, in connection with the causes enumerated, the *fact* that during the wet years evaporation must have been less than during the dry ones, it may be fairly presumed that sufficient apparent causes have existed to produce all the results noticed; and we may add, should such a succession of dry and warm seasons follow, we may look with certainty for a return of the Lakes to the former low level."

In consequence of the great length of the foregoing quotation, I must be content with giving only the following abridged and disjointed particulars on the same subject from Mr. Higgins's Reports of 1839 and 1841:—"That interesting question, the periodical rise and fall of the Lakes, has given rise to a variety of curious speculations. The inference drawn from the following data, is presumed, will not be altogether inconclusive. Calculations may be made sufficiently accurate to determine nearly the amount of surface drained; and if our climate, as is alleged, shows a successive series of cold and moist years, and of warm and dry ones, mutually following each other, variations in the volume of water cannot but be great. Taking into account only the central and upper divisions of the St. Lawrence valley, from Niagara

to the northwest angle of Lake Superior, embracing all the country whose streams are tributary to the Lakes, the surface drained is calculated (as shewn by a table of sections) at 248,775 square miles, besides 86,760 square miles occupied by the Lakes; and it is further calculated that the enormous accumulation of water discharged through the River Detroit during high floods, allowing a current of only one mile an hour, is not less than 95,135,000 cubic feet per hour, or 1,585,558 cubic feet per minute. The floods on Lake Ontario, however, are generally the highest by about two feet; and for this obvious reason, that it receives the successive accumulations of all the Lakes, from the Niagara to the St. Louis Rivers, at the head of Lake Superior.

According to Mr. Mather's report for 1841, which is the next testimony to be adduced: "The preceding year (1840) was the second since the unusual elevation of the waters of the Lakes, since which time there had been a remarkable coincidence in the ratios of subsidence, the more unlooked for when taken in connection with the causes which tend to equalize the amount of falling water in the form of rain, snow and dew, with the constant action of evaporation." * * * * *

"The diminution in a given quantity of water exceeds by evaporation all the supplies which it receives from rain—*i. e*, the average amount of falling water is equal per year to thirty-three inches; but the evaporation will reduce it to forty-four inches, when fully exposed to the sun and air. One season of extreme drought would, upon the expanse of these Lakes produce an extreme depression, while the contrary would produce a corresponding rise. It cannot then be matter of much astonishment that such expanded areas of water, subject to such influences should be greatly affected. The wonder is that they do not oftener present greater fluctuations. The equal and almost unvarying stage at which we find them is due to the conformity of the seasons, and the systematic order in which nature conducts all her works.

"The *semi-annual* alterations observable in summer and winter arise from other well known causes. In summer the supply is unchecked, and the consequence is an increase to the height of about thirty inches; when in winter these supplies are again checked, a consequent depression follows. Measures to ascertain exactly the semi-annual fluctuations have never been thought neccessary. *Besides it is not uncommon for ice in large bodies to collect at the outlets of the Lakes, and for a time prevent the usual discharge, as was the case at the outlet of Lake Huron in connection with a west wind in* 1824 *and* 1831, *when the depth in the Detroit River opposite the City of Detroit was diminished over ten feet.*" * * * * *

"Besides all this, the effect of winds acts sometimes in favor as well as against the other irregularities. The geographical position of the Lakes is such, that allowing them to prevail from the same point at the same time over them all, *which is by no means always the case*, they produce a variety of results. A west wind forces the waters of Lake Erie into the Niagara River, at the same time that the waters from the foot of Lakes Huron and Michigan are forced into the straits of Michilimackinac, and there again are met by the waters of Lake Superior, through the straits of Ste. Marie. Hence the straits which connect Lakes Huron and Erie have all the indications of a tide, though irregular as to time, as well as to the amount of its elevation and depression; and it has often both risen and fallen in about the same proportion and sometimes in the same periods as the lunar tides of those Rivers which empty into the Ocean. But when even these tides take place, either in the Lakes themselves, or in the straits connecting them, they are fortuitous, and the results of accidental disorder common throughout the Lake region. Another feature may be observed in the Lakes, differing in nothing from the ground swell of the Ocean—the reaction of the water, after having been pressed by the wind a few days or hours in one direction;—the most favorable point for noticing which is at an outlet or bay, and Lake Superior having the largest surface presents the most favorable traits of such reaction."

Having thus nearly exhausted my scattered extracts and notes, derived from American authorities, it now remains to refer to a few more memoranda on the same interesting subject, derived from British writers, such as Sir Richard Bonnycastle, Mr. McGregor, Mr. Talbot and others. Among these I turn first to Sir Richard's work on Canada, from which I have taken the following disjointed extracts.*

"The Lakes of Canada have not engaged that attention *at home*, which they ought to have done; and there is much information about them which is a dead letter in England. Their rise and fall is a subject of great interest. The great sinking of their levels of late years, which has become so visible and injurious to commerce, deserves the most attentive observation. The American writers attribute it to various causes; and there are as many theories about it as there are upon all hidden mysteries. Evaporation and condensation, woods and glaciers, have all been brought into play. If the Lakes are supplied by their own Rivers, and by the drainage streams of the surrounding forests; and all this is again and again returned to them from the clouds, whence arises the sudden elevation or the sudden depression of such enormous bodies of water which have no tides? * * * Where do the Lakes receive that enormous supply which restores

* See Bonnycastle's Canada in 1840, pp. 276, 291 to 300.

them to their usual flow? or are they permanently diminishing? I am inclined to believe that the latter is the case, as cultivation and the clearing of the forests proceed; for I have observed within fifteen years the total drying up of streamlets since the removal of the forest; and these streamlets had evidently once been rivulets, and even rivers of some size, as their banks cut through alluvial soils plainly indicate. * * * Perhaps, whenever a *cycle* of years occurs, in which the northeast wind prevails during a year, or a series of years, the Lakes lose their level; for the direction being northeast by southwest such is the usual current of the air, and therefore either northeast or southwest winds are the usual ones which pass over the surface. Whenever southerly winds prevail,—and in the cycle of the gyration of atmospheric currents this is certain, and will be reduced to calculations,—the great Lakes are filled to the edge; and whenever north and northeasterly winds take their appointed course, then these Mediterraneans sink, and the valley of the Mississippi is filled to overflowing. * * * But the most curious facts are that the different Lakes exhibit different phenomena: the Board of Works of Ohio having stated that in 1837–8, the water descending from the atmosphere did not exceed one-third of that which was the minimum of several preceding years.

"Ontario, from the reports of professional men, has varied not less than eight feet; and Erie about five. Huron and Superior, being comparatively unknown, no dates are afforded to judge of them. But what vast atmospheric agencies must have been at work when such wonderful results on the smaller Lakes have been made evident!"

"*What a useful thing*," further observes Sir Richard, "*it would have been, if scientific navigators, or resident observers had registered the rise and fall of the Lakes in the years since Canada came into our possession.*"

Among other unconnected notes I find also some judicious remarks, extracted from McGregor's British America;* but from these I must be content to quote only the following, as referring to a collateral philosophical question of deep interest which may perhaps be touched on in the sequel; namely, the possibility of there being a subterraneous outlet to some of the great Lakes—a hypothesis which I have long been disposed to regard as not altogether irreconcilable with the geological formation of the basins of the middle and lower lakes, though perhaps not so with the structure of the Lake Superior regions; it being doubted whether, notwithstanding the great annual evaporation, the volume of water discharged by Lake Erie *does* sufficiently account for the vast united supply received by it from the immense triple resources of Lakes Superior, Michigan and Huron.

* See McGregor's British America, vol. i, pp. 131 to 133.

"As the temperature of the climate in America depends chiefly on the winds, the formation of that continent is evidently the cause of the frosts being more intense than in countries in parallel latitudes in Europe; a consequence arising principally from the much greater breadth of America towards the poles. Winds change their character in America. Northeast winds, which are cold and dry in Europe, are wet and truly disagreeable in America. Northwest winds are, on the contrary, cold and dry, and are frequent during winter in America, much about the same period that northeasterly winds prevail in Europe. One great, if not the principal, cause of cold in America, is the direction of the mountainous ranges and basins of country which conduct or influence the course of the winds. While the sun is to the south of the equator, the winds less under solar influence prevail from the northwest, following, however, the great features of the continent. The winds blowing over the vast regions of the north are always piercing and intensely cold. The return of the sun, again, by the diffusion of heat, agitates the atmosphere and alters the winds, which blow from a contrary direction, till the equilibrium is produced. This, however, does not appear to require much time, as no wind blows scarcely forty hours together from any one point.

"The comparative depths of the Lakes forms another extraordinary subject of enquiry. The bottom of Lake Ontario, which is 452 feet deep, is as low as most parts of the Gulf of St. Lawrence, while Lake Erie is only 60 or 70 feet deep; but the bottoms of Lakes Huron,* Michigan and Superior, are all, from their vast depth, although their surface is so much higher, on a level with the bottom of Lake Ontario. This is certainly not impossible; nor does the discharge through the Detroit river—allowing for the full probable portion carried off by evaporation—appear by any means equal to the quantity of water which the three upper great Lakes may be considered to receive. All the Lakes are estimated to cover 43,040,000 acres. The great Lakes occasionally rise above their usual level from three to five feet. These overflowings are not annual nor regular. They have occurred about once in seven years, and are probably the effect of more rain and less evaporation during the seasons in which they take place. Sir George Mackenzie observed occasional overflowings of two to three feet in the Lakes northwest of Lake Superior; so that they are not peculiar to the Lakes of the St. Lawrence."

Having at length nearly exhausted my miscellaneous quotations and notes, I propose concluding that main branch of my task with the following appropriate remark, derived from a note

* As an instance of our ignorance of the true depth of some of our Lakes, it is proper to note here that that of Lake Huron has, after all, been lately ascertained by the American Coast Survey to be not more than 420 instead of 860 feet!—R. L.

at page 133 of the 1st volume of Talbot's Canada, as not only bearing on the now generally admitted influence of prevailing winds on the temporary fluctuations in the level of the Lakes, but also as adverting to the almost equally demonstrable fact, that the singular *severity* of our Canadian winters, and more particularly those of Lower Canada, compared with European countries in the same parallels of latitude, is altogether uninfluenced by the vast extent of our Lakes; on which subjects the author referred to, quoting an American author, states as follows:—

"Professor Dwight has proved that the height of the river (Niagara) both above and below the Falls, depends on the quarter from which the wind blows. Lake Erie, he says, is regularly raised at the eastern end, where the Fall commences, by every wind blowing between northwest and southwest. A strong westerly wind elevates its surface six feet above its ordinary level. The rivers must, of course, be proportionally elevated; and at the outlet must, when such a wind blows, be six feet higher than the *usual* water mark. * * On the contrary, when the wind blows from the northeast (the only easterly wind which in this region is of any importance), the waters of Lake Erie must recede of course, and fall considerably below their usual level, and the river be necessarily lower than at any other time."

The same author, in another part of his work (pp. 339 to 342), remarks as follows, with regard to the climate of Canada differing from that of European countries in a similar latitude:

"The cause of this phenomenon appears to have eluded the most diligent and profound research. Many writers attribute the severity of the winter to the astonishing prevalence of northwest winds, and the amazing extent of the Lakes. That the severity of the weather in winter cannot with any propriety be attributed to the influence of the Lakes will appear evident to every man who reflects that the shores of those great inland seas enjoy a much milder climate than any other part of the country in the same parallels of latitude, however remotely situated from them. Fruit trees thrive well and bring their fruits to great perfection along the northwest extremity of Lake Ontario, in lat. 43 deg. 30 min., and along the north shore of Lake Erie; and yet at 35 miles from the latter place, and in lat. 42 deg. 20 min., this fruit cannot be cultivated; and I have also seen snow three feet in depth a degree south of Lake Ontario, while at the same time it did not exceed six inches in the immediate vicinity of that Lake."*

(*To be continued.*)

* See the letter introductory to my late paper on the establishment of a system of meteorological observations; and also the note at the foot of page 293 of this Journal.

Art. XVII.—*On the Clinochlore of Achmatowsk;* by N. von Kokscharov.*

The green mineral of Achmatowsk, remarkable for its dichroism and its perfect cleavage, was for a long while regarded as identical with the chlorite of Werner. Von Kobell† first remarked the difference from that species of both the Achmatowsk chlorite and another of like characters from Schwarzenstein, and gave to them the name ***ripidolite*** (from ῥιπις, *feather* and λιθος *stone*). G. Rose, observing that the name ripidolite was more appropriately descriptive of Werner's mineral than of that of Achmatowsk, reversed the use of the names ripidolite and chlorite, giving the former to the St. Gothard and Rauris mineral and the latter to von Kobell's ripidolite. Recently, a mineral from Westchester, Pa., has been described by W. P. Blake, as Clinochlore, which is not different from the Achmatowsk species.

The crystals of Achmatowsk according to von Kobell are hexagonal. All other mineralogists have adopted this view. At the suggestion of my esteemed instructor, G. Rose, I made in 1851 many measurements of the crystals, and in my paper I also described it as hexagonal.‡

[The author here observes that his former measurements were made with great care with the reflective goniometer; and that although discrepancies with calculation were observed, and the planes were not always simple in their crystallographic signs, the habit of the crystals appeared to be hexagonal, and this view was hesitatingly adopted. He then proceeds, as follows.]

The observations on my labors of G. Rose and M. Kenngott, and especially a letter from J. D. Dana giving a description of the Clinochlore and its analysis by Mr. Craw, led me to suspect that the crystallization of the Achmatowsk chlorite was *monoclinic.*§

As the Achmatowsk mineral has now proved to be monoclinic and its name has been the occasion of some perplexity in the science, I propose to retain the name Clinochlore for the species, including with it also the Schwarzenstein mineral; and I have consequently placed this name at the head of this article.

* Read before the Akademie der Wissenschaften zu St. Petersburg, Sept. 20, 1854, and published in volume xiii. of their Memoirs.

† Jour. f. pr. Chem., xvi, 470, 1839.

‡ Verhandl. der K. K. Min. Ges. St. Petersb., 1850 and 1851, p. 163, and Pogg. lxxxv, 519.

§ [The notes in the original giving the remarks of G. Rose, and Kenngott, and an extract from the letter of J. D. Dana, are here omitted.—Eds.]

The clinochlore of Achmatowsk is a very beautiful mineral species. It accompanies handsome crystallized varieties of garnet, diopside, apatite and other species, in which this locality is so very rich. Many of the crystals are tabular, while others are lengthened in the direction of the vertical axis, and often they are in druses. A large part of the crystals are unfit for measurement by the reflective goniometer; but there are some small ones which afford good results. The planes observed are as here enumerated.*

O (P)			
$\frac{1}{3}$-∞ (*y*)	$\frac{2}{3}$ (*n*)		
	$\frac{4}{3}$ (*m*)		
1-∞ (*i*)	1 (*o*)		
		$\frac{3}{2}\breve{3}$ (*s*)	
		2-$\breve{3}$ (*c*)	
			3-$\breve{\infty}$ (*k*)
4-∞ (*z*)			4-$\breve{\infty}$ (*t*)
	∞ (M)	∞ -$\breve{3}$ (*v*)	∞-$\breve{\infty}$ (*h*)
	-6 (*d*)	-6 $\breve{3}$(*w*)	
-4-∞(*x*)			
	-2 (*u*)		

Observed Planes.

The most important combinations are as follows:

I.—0, -4-∞, $\frac{2}{3}$, 1, ∞, $\frac{3}{2}\breve{3}$, 4-$\breve{\infty}$.

II. (fig. 1)—0, $\frac{2}{3}$-∞, 1-∞, -4-∞, $\frac{2}{3}$, 1, -2, $\frac{3}{2}\breve{3}$, 4-$\breve{\infty}$.

III. (fig. 2)—0, 1, ∞, 4-$\breve{\infty}$, ∞-$\breve{\infty}$.

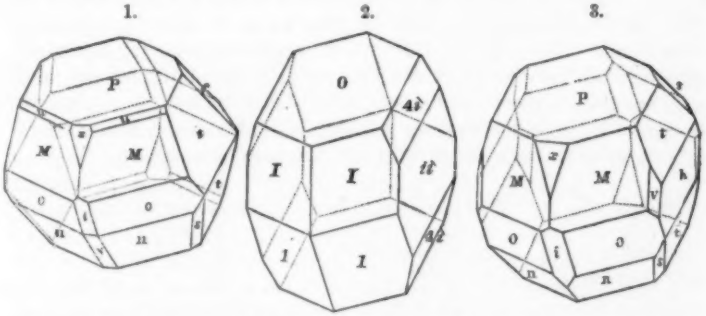
IV. (fig. 3)—0, 1-∞, -4-∞, $\frac{2}{3}$, 1, ∞, $\frac{3}{2}\breve{3}$, ∞-$\breve{3}$, 4-$\breve{\infty}$, ∞-$\breve{\infty}$.

V.—0, $\frac{2}{3}$, ∞, 4, $\breve{\infty}$.

VI.—0, $\frac{2}{3}$, 1, ∞, 4-$\breve{\infty}$, ∞-$\breve{\infty}$.

VII.—0, $\frac{2}{3}$-∞, 1-∞, 4-∞, $\frac{2}{3}$, ∞, 2-$\breve{3}$, ∞-$\breve{3}$, -6-$\breve{3}$, 4-$\breve{\infty}$.

VIII.—0, 1-∞, 4-∞, 1, ∞, 2-$\breve{3}$, ∞-$\breve{3}$, 4-$\breve{\infty}$.



Putting *a* for half the vertical axis, *b* for half the clinodiagonal, *c* for half the orthodiagonal, and C for the inclination of the vertical axis or *a* on *b*.

[* The planes are here presented in a table according to the method of J. D. Dana, showing the several zones of planes; the 1st column being the zone parallel to the orthodiagonal; the 2nd, the fundamental zone; the 4th, that parallel to the clinodiagonal. The symbols are essentially Naumann's, except that the letter P is dropped. The letters used by Kokscharov on his figures are also given.—Only part of the figures of the memoir are here copied. In figure 2, the lettering is altered, to correspond with the notation, only *i* is wiritten for ∞; O, I, 1, 4*i*, *ii* are respectively P, M, o, t, h, of Kokscharov.— D.]

Also, μ for the inclination of the clinodiagonal terminal edge on the axis a; ν, for the same on the diagonal b; ϱ, for the inclination of the orthodiagonal, terminal edge on the axis a; X, for the inclination of a face of P on the clinodiagonal section; Y, ibid on the orthodiagonal section; Z, ibid on basal section.

And also: X′, Y′, Z′, and μ', ν', for the corresponding angles in the negative hemipyramid:—we then find

$a:b:c=1{\cdot}47756:1:1{\cdot}73195$*		C=62° 50′ 48″
X = 60° 44′	Y=48° 53′	Z =77° 54′
X′= 70° 22′	Y′=31° 10′	Z′=42° 12′
μ= 41° 4′	ν =76° 5′	ϱ =49° 32′
σ= 60° 0′	μ'=24° 42′	ν' =38° 8′

The angle σ being 60°, therefore the plane angles of the basal planes are 120° and 60°, or when the acute angle is replaced, a regular hexagon. This hexagonal character is also strongly shown in the planes of the zone m-3, whose intersections with the edges of the basal plane are 150°, and which correspond to the zone m-2 (or intermediate hexagonal pyramids and prisms) of the hexagonal system. The compound crystals consisting of three crystals, which are common in the clinochlore of Achmatowsk, have a still greater similarity to a hexagonal prism.

It is also to be observed that the angle C, 62° 51′, is nearly half the angle of M : M, or 125° 37′—half of 125° 37′, being 62° 48½.

In the crystals, the hemipyramids of the fundamental series are mostly more or less striated parallel to their intersection with P(0), and seldom smooth and shining so as to afford good measurements. The faces of the clinodiagonal zone m-$\bar{\infty}$, are rather smooth and lustrous; but the face P, and the planes of the zone m-$\bar{3}$ are the brightest and smoothest. The following angles are obtained by calculation from the values of the axes given, excepting those with an asterisk which are measured angles:

oP 102° 7′ (102° 6′†)	*mm* 125° 24′	*sh* 140° 39′
oM 143° 57′	*mM* 132° 35′	*cP* 107° 26′
on 163° 34′	*uP* 127° 43′	*cn* 150° 20′
ot 122° 0′	*uM* 166° 14′	*ct* 151° 28′
ou (over M) 130° 10′	*ux* 155° 49′	*cv* 148° 11′
oo (over *i*) 121° 28′	*ut* 124° 33′	*cw* (over *v*) 138° 30′
oh 119° 16′	*uh* 113° 18′	*wP* 114° 4′
nn (over *y*) 127° 53′	*uu* 133° 24′	*wM* 152° 38′
nP 118° 32′ (118° 28′†)	*dP* 118° 59′ (119° 5′†)	*wt* 151° 29′
ny 153° 57′	*dM* 174° 58′	*wh* 142° 15′
nM (over *o*) 127° 31′	*dt* 124° 33′	*ww* 170° 19′
nt 124° 31′ (124° 31′†)	*dh* 115° 56′	*wn* 119° 59′
mP 113° 28′	*dd* 128° 7′	*wo* 133° 27′
mi 150° 6′ (150° 0′†)	*st* 151° 5′	*MP* 113° 57′ (113° 57′†)
mh =117° 13′	*sn* 153° 26′	*Mt* 124° 8′ (124° 4′†)
mt 124° 4′	*so* 148° 16′	*Mh* 117° 12′
mk 125° 27′	*sP* 116° 45′	*MM* 125° 37′ (125° 38′†)

* Obtained from the measured angles; M : M = 125° 37′; M : P = 113° 57′; P : o = 102° 6½′. † Observed angles.

vP 75° 37′	*kk* (over *P*) 47° 25′	*yo* 145° 57′
vM 150° 10′	*tP* 108° 14′	*yP* 122° 8′
vt 150° 59′	*th* 161° 46′	*zP* 72° 7′
vh 147° 1′	*tt* (over *h*) 143° 33′	*zi* 148° 12′
vv 65° 57′	*iP* 103° 55′	*xy* 129° 59′
kP 113° 42′	*io* 150° 44′	*xP* 125° 7′ (125° 4′*)
kh 156° 18′	*in* 148° 35′	*xM* 151° 45′
kk (over *h*) 132° 35′	*iy* 161° 47′	

For the forms, X, Y, Z, etc., have the following values:

Form		X		Y		Z		μ		ν		ϱ		σ	
	$\frac{3}{2}$	63°	57′	62°	41′	61°	28′	59°	17′	57°	52′	60°	22′	60°	00
	$\frac{4}{3}$	62	12	58	19	66	32	53	47	63	23	57	23	60	00
	−2	66	42	27	17	52	17	14	37	48	14	30	22	60	00
	−6	64	04	26	28	61	01	5	27	57	24	11	03	60	00
	$\frac{3}{2}$-3	39	21	78	57	63	15	72	23	44	46	38	00	30	00
	2-$\breve{3}$	34	17	73	17	72	34	59	17	57	52	30	22	30	00
	−6-$\breve{3}$	37	45	53	41	65	56	14	37	48	14	11	03	30	00
	∞	62	48½	27	11½										
	∞-$\breve{3}$	32	59	57	1										
	3-$\breve{\infty}$	23	42			66	18								
	4-$\breve{\infty}$	18	14			71	46								
	1-∞			41	04	76	05								
	$\frac{3}{2}$-∞			59	17	57	52								
	4-∞			9	16	107	53								
	−4-∞			7	57	54	53								

Cleavage very perfect parallel with the base. G.=2·774 according to G. Rose. H.=2·5. Strongly dichroic, being green in the direction of the vertical axis and brown or hyacinth-red transversely, and the colors seldom so different in other dichroic species. Streak-powder light greenish-white. The largest crystals often only translucent on the edges; the smaller subtransparent. Flexible in thin plates but not elastic.

Although the basal plane is usually smooth and shining, there is in some crystals an unevenness which indicates by its stellate appearance a regular composition. In the crystals of Achmatowsk, this compound structure is quite common; they consist of three simple crystals, compounded parallel to the plane $\frac{3}{2}$. Since the faces of the form $\frac{3}{2}$ are inclined to the clinodiagonal section 60°, and to the basal plane 89° 43′, the three crystals will meet at angles of 60°, and have their basal planes inclined to one another 179° 25′, or very near 180°.† The large crystals are often also made up of a mixture of small crystals with their basal planes grouped in rosettes, as happens in the specular iron of St. Gothard.

* Observed angle.

† It might be suspected from such twins which are like those of Aragonite, that the plane $\frac{3}{2}$P may make an angle of 90° with the base, (as in the mica of Vesuvius); but the appearance of salient and reëntering angles on the cleavage face of these compound crystals seems to be good evidence that the angle between $\frac{3}{2}$P and the base is not a right angle. In the collections of P. von Kotschubey, there is a large druse of Clinochlore crystals in which each is a twin of three crystals. [In twins from Westchester, there is no reëntering angle, the cleavage plane being perfectly smooth.— D.]

According to G. Rose, the Clinochlore of Achmatowsk has the following characters: B.B. on charcoal intumesces, becoming yellowish brown and opaque: in the platinum forceps, fuses with a strong heat on the outer edges to a black glass. In a tube undergoes the same changes as on charcoal giving little water with no fluoric acid. With borax dissolves easily to a clear glass, colored by iron; with salt of phosphorus a similar glass, the silica separating; with soda on charcoal, a brown swollen mass which fuses with difficulty. With sulphuric acid wholly decomposed. Analyses by von Kobell (J. f. pr. Ch. xvi, 470), Varrentrapp, (G. Rose, Reise n. d. Ural, 1842, ii, 127 and Pogg., xlviii, 189) and Marignac (Ann. de Ch., x, 430).

	$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{M}g$	$\dot{H}$	Insol.
1.	31·14	17·14	3·85	0·53	34·80	12·20	0·85=100·11
2.	30·38	16·97	4·37	——	33·97	12·63	—— = 98·32
3.	30·27	19·89 $\dot{F}e$	4·42	——	33·13	12·54	—— =100·25

Varrentrapp deduces the formula,

$$(\dot{M}g, \dot{F}e)^3\,\dot{S}i + \dot{A}l\,\dot{S}i + 2\dot{M}g\,\dot{H}^3.$$

This composition does not differ from that of the Clinochlore of Pennsylvania.

I shall have to revise my comparisons of the described chlorites, after this reference of the Achmatowsk mineral to the monoclinic system, with the exception of the Schwarzenstein chlorite (ripidolite of v. Kobell), as they cannot stand, since we do not know to which zone the described planes of these chlorites belong. I may here observe that none of the angles obtained by Frobel and Descloizeaux in Pennine, are yet found in either of the zones of the Achmatowsk chlorite. The same is true of the Kämmererite. The resemblance of the clinochlore crystals to hexagonal forms, renders it desirable that there should be a revision of the crystallography of all these minerals.

The optical characters of our crystals have not yet been fully studied. I can only state that the laminæ of the Achmatowsk clinochlore examined with the tourmaline, allows the light to pass when the axis of the tourmaline plates are at right angles—in which respect it does not differ from biaxial crystals. There is a strong probability therefore, that the optical characters are like those of the Pennsylvania Clinochlore. In this last, Mr. W. P. Blake, examining a triangular plate, found that the two axes lie in the same plane which was at right angles with one side of the triangle; and this plane therefore lies in a clinodiagonal section. According to Blake, one of the optical axes is inclined at an angle of 27° 40′, and the other at 58° 13′, making the angle between them 85° 53′ and 94° 7′.

Mr. Blake has observed in another specimen a second system of axes, the plane of which makes an angle of 60° with the first, which indicates that the specimen was a compound crystal.

[The paper closes with an enumeration of the measurements of crystals of the Achmatowsk Clinochlore with a Mitscherlich's goniomer, by which the angles were obtained. The mean for P : M from 12 measurements of one crystal was 113° 58′; (the extremes 113° 57½′ and 113° 58¾′) from another 113° 56′; from a third 113° 56¼′; giving for the mean of the three 113° 56¾′. For M : M from No. 1, 125° 38′, for No. 2, 125° 37′. For P : o from crystal No. 3, 102° 6½′; from crystal No. 5, 102° 6′; from crystal No. 3, P : n = 118° 28′; from No. 6, P : t = 108° 11′; from No. 2, M : t = 124° 3½; from Nos. 2 and 3, t : n = 124° 32′; from No. 4, 124° 30′; from No. 4, P : x = 125° 4′. From No. 7, P : d = 119° 5′, m : i = 150° 0′.]

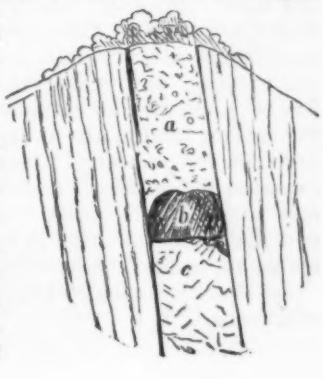
ART. XVIII.—*A brief notice of some facts connected with the Duck Town, Tennessee, Copper Mines;* by M. TUOMEY, State Geologist, Ala.

KNOWING that Dr. Curry of Nashville, and Mr. Proctor of the Tennessee Mines, are preparing a memoir, that will include the history, geological and economical relations of these mines, I intend to confine myself to a fact or two that I observed during a hurried visit to the place, and which may be worth being placed upon record.

Notwithstanding the excitement produced by the discovery of these mines, the current accounts of the richness of the ore, and great thickness of the beds, are not greatly exaggerated.

In a short but very lucid report, Mr. Whitney has presented a clear view of the state of some of these mines which he was commissioned to examine, together with a section which represents the geological character of the country for a distance of 40 miles. The road to the mines, which lies along the banks of the Ocoee river, exposed an admirable section of 24 miles in length.

The mines are situated at the junction of the silurian and metamorphic rocks,—or as Mr. Whitney suggests, the cupriferous slates may be altered silurian strata.



The accompanying cut presents the position, and relation of the metalliferous beds at all the mines: *a*, upper portion of the bed composed of a porous, amorphous mass of red and brown oxyd of iron, the *gossan* of the Cornish miners, *iron hat* of the Germans, which is the residue of the ore after the copper

has been dissolved out. This process, the solution of the ore, is constantly, though, of course, slowly going on, as may be seen at the works, and hence the very variable thickness of the ore *b*. From portions of the bed every trace of copper has disappeared, down to *c*. The copper ore *b*, is a bluish black altered sulphuret. That the alteration is due to heat is rendered highly probable by the vesicular structure of the ore itself, as well as by the joints with which it is intersected, and which correspond in direction with those of the surrounding rocks of the country.

In every published account of these mines that I have seen, the impression is left, that the ore *b* is derived from the underlying portion of the bed *c*, by decomposition. Now *c* has been reached in all the mines, and invariably consists of arsenical iron, with rarely more than one per cent. of copper in the form of yellow sulphuret, and consequently could not furnish by decomposition or any other conceivable process, an ore containing 20 per cent. of that metal.

This lower arsenical iron portion *c*, of the bed is found everywhere immediately underlying the black ore, at no great distance below the surface, and is frequently met with even in the levels driven in the hill-side.

The whole of that portion of the bed above *c*, doubtless once consisted of yellow sulphuret of copper, and the part below *c*, as at present, of arsenical iron. During the metamorphism of the slates the sulphuret was altered to the black ore, and subsequently the soluble salts derived from this ore, were dissolved out by the simple process of leaching, the residual *gossan*, or *iron hat* being left in the upper portion of the bed, and the still unbleached ore, resting on the arsenical iron.

It is remarkable that this same arsenical iron with a little copper, is found in some of the shafts sunk, in exploring for copper in Alabama.

The solution of the question, What is below the arsenical iron? is a most interesting subject in connection with the value and future prospects of the mines. At one place a shaft has been sunk in the arsenical iron, to a depth of 10 or 12 fathoms without showing any encouraging change, and at another a shaft has been commenced calculated to cut the bed, 50 fathoms below the present level of the mine, or, as it is called in the mining reports, for the purpose of "proving the yellow sulphuret." These experimental shafts, if continued, will be of the utmost importance to the whole copper region, including portions of Georgia and Alabama. Should this arsenical iron terminate, at a moderate depth, in the yellow sulphuret, then indeed may Tennessee boast of such mines as are not found in the history of mining operations.

ART. XIX.—*On the Periodical Variations of the Declination and Directive Force of the Magnetic Needle;* by W. A. NORTON, Professor of Civil Engineering in Yale College.

THE direction in which the magnetic force of the earth solicits either end of a magnetic needle is ascertained by suspending the needle freely by its centre of gravity. It is well known that throughout the greater part of the northern hemisphere the north end of a needle thus suspended is depressed below the plane of the horizon; and that throughout the greater part of the southern hemisphere the south end is depressed below this plane; also that this *inclination* or *dip* of the needle gradually increases from the *magnetic equator*, where it is zero, in both directions to the magnetic poles, where it is 90°. Such then are the varying directions of the directive force of the magnetic needle at different points of the earth's surface. The two ends or poles of the needle are solicited in opposite directions; the north end downward, and the south end upward. It suffices in discussing the perturbations to which the earth's magnetic force is subject, whether of direction of intensity, to confine our attention to the action upon one end of the needle, for example the depressed end,—(north end in the northern hemisphere, and south in the southern hemisphere); since the repelling force, acting upon the more elevated end, experiences corresponding changes, and has uniformly the same tendency, in giving direction to the needle. If now the directive force be decomposed into two components, the one horizontal, and the other vertical, we have what are called the *horizontal force*, and the *vertical force*, acting upon the needle; or the horizontal and vertical magnetic intensities of the place. These two forces, together with the *declination* (or deviation of the line of direction taken up by the horizontal compass needle, from the true north and south line) constitute what are called the *Magnetic Elements* of the station. Each of these elements changes in value as we pass from one station to another. It is well known also that at any one station they are not at all times unalterably the same; but are subject to variation from hour to hour, from day to day, and from year to year. The changes from hour to hour during the period of a day we call the *Diurnal Variations;* those from day to day, during the period of a year, we call the *Annual Variations;* and the change from year to year, the *Secular Change.* In a more restricted sense we call the entire amount of the change, whether of increase or diminution, in a day, the diurnal variation of the element; and we often attach a similar signification to the term annual variation, of a magnetic element. But, in the present paper I shall generally use these terms in the most

comprehensive sense; that is as comprising all the variations that occur during the day, whether we compare them hour by hour, or by longer intervals.

There are two classes of diurnal variations of the magnetic elements—viz, those which are *Periodic* and those which are *Irregular*, or more properly *Occasional*. Thus any one element, as the declination, regularly increases during a certain portion of every day, and then as regularly decreases during another portion of the day. Changes also occur, to all appearance fortuitously, at any hour of the day; so that their occurrence cannot be predicted for any one hour. Still it is now known that the irregular variations, so called, are under the control of certain overshadowing laws; thus they occur more frequently, and are larger in amount at certain hours than at other hours, and at certain parts of the day the liability is to an increase, at other parts to a diminution. If we compare the amount of the declination, or other element, at any hour of the day, with the same at the same hour of the following day, we find that a change has occurred, and if we do the same throughout the year we discover that the element in question, or its amount at a particular hour increases during half of the year, from a certain day, and decreases during the remaining half; in other words, it undergoes a regular variation, the period of which is a year. The amount of the change of the declination, or horizontal or vertical force, that takes place during a day, also varies from one season to another. Besides the periodic variations whose period is a day, or half a day, or a year, there is another class, recently discovered, whose period is about ten years (10 to 11 years). Thus, it is found that the amount of the alternate increase and decrease of the declination during a day is greater some years than others, and that it alternately augments and diminishes during a period of ten or eleven years. It is an interesting and very important fact, in a physical point of view, that this period has been found to be identical with that of a change which has been observed to occur in the number and magnitude of the spots on the sun from year to year, the maximum and minimum of the one quantity coinciding also in point of time with the maximum and minimum of the other quantity. Thus the year 1843 was that in which the mean daily movement of the needle, for the year, was the least, and also that in which the number and magnitude of the solar spots was the least. The year 1838 was the epoch of the previous maximum for both. The changes are very marked; the number of groups of solar spots observed by M. Schwabe during the year 1843 was 34, during the year 1838, 282; the mean daily movement of the needle at Toronto for the entire year, was $8'{\cdot}90$ in 1843, and $12'{\cdot}11$ in 1848, (the year of the following maximum). It has been still more recently established,

that the irregular variations, so called, undergo similar changes during the period just mentioned—the *solar period*, as it may be termed, by way of distinction.

It is now about twenty-five years since the project was conceived, by Baron Humboldt, and partially carried into execution, of covering the earth with magnetical observatories, at which "simultaneous observations should be made of every regular and irregular excitement of the earth-force." Since the year 1840, magnetical observatories have been in systematic operation in all parts of the earth, "from Toronto, in Upper Canada, to the Cape of Good Hope, and Van Diemen's Land, from Paris to Pekin;" provided with the magnetometers contrived by Gauss in 1832. These are large magnets delicately suspended, and carrying a small mirror, in which the observer, looking through a small telescope firmly fixed on a stone pier, sees the reflection of the fixed scale, and thus observes with great precision the smallest movement of the magnet. The horizontal force magnetometer is brought by the torsion of its suspension wire into a position at right angles to the magnetic meridian, and shows by its motions the variations of this force. The vertical force magnetometer devised by Dr. Loyd of Dublin, admits of motion only in a plane perpendicular to the magnetic meridian. The bar rests by a knife edge, on agate planes, and is adjusted by a ball moveable upon a fine screw, so as to deviate a little from the truly vertical position. In its improved form it carries a mirror at right angles to the plane of the bar, like the declination and horizontal force magnetometers. With these magnetometers a change of magnetic intensity amounting to the $\frac{1}{4000}$th part is measured. The changes of declination are shown by the declination magnetometer, or declinometer, to within 2″ to 3″ of the truth. In this "net work of stations provided with similar instruments" are especially to be noticed the British Colonial Observatories (at Toronto, St. Helena, Cape of Good Hope, and Hobarton in Van Diemen's Land) which began operations in 1840, and the Russian Observatories scattered over the Russian Empire, which were erected about ten years earlier. Hourly or bi-hourly observations have been made at these and at many other observatories in Europe and elsewhere, for many years; and on certain days, called Term Days, they have been noted as often as every $2\frac{1}{2}$ minutes. We have now several volumes of Reports of the magnetical and meteorological observations made at the British Colonial Observatories, with abstracts, discussions, &c., published under the direction of Colonel Edward Sabine. Annual Reports of the observations made at the Russian Observatories have also been published, under the superintendence of Professor Kupffer. Reports of the observations made at the Girard College Observatory, and also at Washington, under the direction respectively of Professor

Bache, and Lieutenant Gilliss, during the years 1840–1845, have also been published. To separate the regular from the irregular variations, and ascertain the changes that occur from one season to another, &c., the means of the magnetometer readings at each observation hour, for periods of a month, three months, half a year, or a year, are calculated and published in a tabular form: and their variations are also graphically represented by curves, the abscissas standing for the observation hours, and the ordinates for the magnetometer readings.

Such are the materials from which I have for the most part derived the specific data, and general facts and laws used in the present discussion. In my first investigations on the present subject, commenced several years since, I undertook to determine how far the diurnal variations of declination, &c., might be *represented* by changes of temperature, directly and indirectly. In a paper read before the last meeting of the American Association for the Advancement of Science (held in Washington in April, 1854,) I stated that I had satisfied myself, by an examination of the Toronto observations, that no direct connection could be traced as subsisting between the disturbances of the magnetic needle, whether regular or irregular, and meteorological changes of any kind, occurring at the place; and that accordingly if the principle of terrestrial magnetism exhibits grand features of correspondence to that of terrestrial heat, in its normal aspect, and its more prominent variations, on a nearer view dissimilarities stand revealed, which indicate that another direction must be taken if we wish to gain an insight into the real physical cause of magnetic disturbance. Granting that the perturbations of the earth's magnetic force occur without any reference to meteorological changes that happen at the earth's surface, or in the lower atmosphere, we are led to conclude that the seat of magnetic disturbance is located either in the upper regions of the atmosphere, or is coëxtensive with the magnetic matter that pervades the atmosphere and is distributed through the crust of the earth. Taking up the former idea, I advanced certain reasons for supposing that the sun could only act by some emanation, and undertook to follow out the consequences of a supposed emission of some form of magnetic matter from the sun, and the flow in every direction over the surface of the atmosphere of the streams of this matter that would descend upon the equatorial regions. In the present memoir I have adopted the idea that currents of electricity are excited in the upper atmosphere, *by the sun's action*, and flow in every direction along its surface; also that currents are developed by the sun which flow in a direction parallel to his equator, or nearly parallel to the ecliptic, and from East to West. The conception I have formed of the nature of this action is that it consists in the propagation by ethereal waves of a

vibratory motion, or rather an impulse, from the sun to the upper atmosphere. But it should be observed that the question of the truth of this physical conception is entirely distinct from that of the satisfactory explanation of the magnetic perturbations, by the fundamental idea of electric currents just stated. This elevated region, surrounding the earth, whether it be entirely comprehended within the atmosphere, or be more or less exterior to it, I shall call the *Photosphere* of the earth; under the idea that the luminous phenomena, the Aurora Borealis and Aurora Australis, probably occur in this region. At times, I may designate it as the *upper atmosphere.*

Before entering upon a particular examination of the diurnal variations of the magnetic elements that occur at any one place, it will be well to consider how far the laws of these variations are the same in different parts of the earth. The following are the principal results which have been obtained on this point:

1. The laws of the diurnal variations are essentially the same at all places to the north of the Torrid Zone; they are also the same at all places to the south of the Torrid Zone. The only difference noticed is in the amount of the variations, and in the precise hours of the maxima and minima.

2. The laws are the same in the Southern Hemisphere without the Torrid Zone, as in the Northern, if we observe that in the Southern Hemisphere the south end of the needle answers to the north end in the Northern Hemisphere. Accordingly, at the same local hours the north end of the needle is moving in opposite directions at stations in the two hemispheres, without the tropics.

3. At stations situated between the Tropics, the laws of the diurnal movement are not the same throughout the year, as they are very nearly in other parts of the earth; at certain local hours the needle moves in the one direction or the other according as the sun is north or south of the equator.

I may here state that the theoretical views advanced in the progress of the present discussion all have their foundation in one fundamental physical idea with regard to the nature of the electric excitement induced by the sun, and the sun's mode of action. But the physical aspect of the question must, of necessity, be held in abeyance for the present. Let the present inquiry be simply, whether there is any conceivable system of electric currents, which will explain all the diversified laws of the diurnal and annual variations of the declination of the needle, at all the different points of observation, and which will equally well explain the laws of all the variations of the horizontal and vertical forces. If so, it can hardly be doubted that the hypothesis is either a veritable reality, or has its counterpart or equivalent in nature. If it stands the test of quantitative determinations, the conviction of its truth will be strengthened.

It may be well to meet at the outset an objection that may occur to some of my readers. It is implied in what follows (although not perhaps of necessity) that the atmosphere derives its principal electric excitement from a solar action upon its upper regions; when it has generally been supposed hitherto that atmospheric electricity has its origin in the evaporation going on at the earth's surface. But in fact, the old theory of the origin of atmospheric electricity has no longer any basis to rest upon. According to Becquerel, and other able experimenters, electricity is not generated by evaporation unless salts are present in the water. "Some years since M. Riess and M. Reich showed that the electricity attending evaporation proceeded from the friction of the water against the sides of the vase. This fact is proved anew by the researches just published of M. Gaugain, although the results differ in the details from those of the German physicists." If the fact be admitted that the atmosphere is electrically excited by some action of the sun, our views of certain meteorological phenomena must be modified, and we may derive new light with regard to some of these phenomena hitherto enveloped in mystery.

It should be observed that the idea of the magnetic needle, at the earth's surface, being disturbed by electric currents circulating in the upper regions of the atmosphere cannot be regarded as an hypothesis, since we know from observation that the needle is disturbed by the Aurora Borealis, and that this phenomenon is unquestionably attended with the circulation of electric currents in the upper atmosphere. In fact the aurora, with its attendant electric excitement, and electric currents, is the only known terrestrial cause of magnetic disturbance.

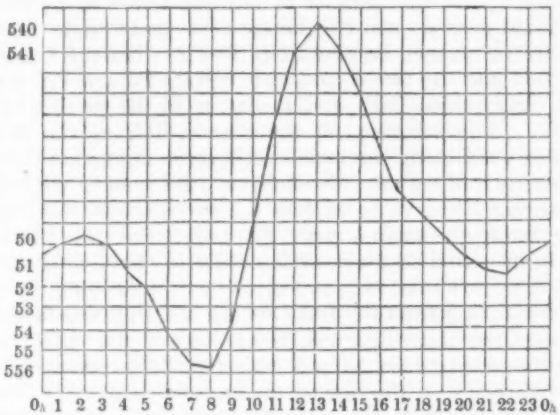
DECLINATION.

It is to be recollected that the declination at any particular place may be either East or West; and that in the Southern Hemisphere, as well as in the Northern, it is defined by the position of the North end of the needle with respect to the North point of the horizon.

Diurnal Variations.

The laws of the diurnal variations of declination are graphically represented in the annexed diagram, (Fig. 1.) On examining it it will be seen that the needle has its minimum of declination, or in other words, that its north end has its most easterly position at 8 A. M. At this hour it begins to move toward the west, and continues to do so until 1 P. M., when it has attained to its maximum of westerly deviation. It now begins to return toward the east, or its declination decreases, and this movement continues until 10 P. M. when there is a second minimum of declination. From 10 P. M. to 2 A. M., there is a small westerly movement again,

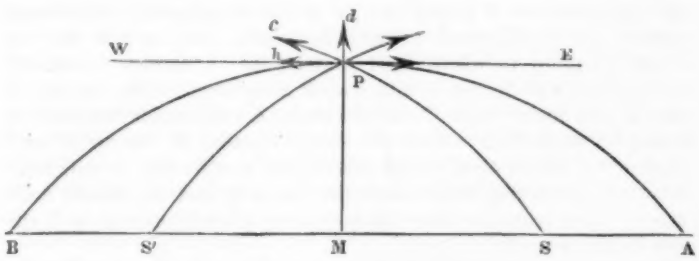
1.—*Curve showing the Mean Diurnal Variations of the Declination at Philadelphia, for the year* 1844.



Increase of numbers at the side corresponds to decrease of declination: 0h *answers to midnight.*

and from 2 A. M. to 8 A. M. a greater easterly movement. Thus the declination has two maxima, viz., at 1 P. M., and at 2 A. M., and two minima, at 8 A. M. and 10 P. M. The principal maximum is at 1 P. M., and the principal minimum at 8 A. M. The principal disturbance occurs during the day, and consists in an increase of declination or a westerly movement, from 8 A. M. to 1 P. M., and a decrease of declination, or an easterly movement, from 1 to 10 P. M. The disturbance at night, is of the same nature, but much less in amount; that is, the north end of the needle first moves toward the West and afterward toward the East.

2.



Now let P (Fig. 2) be the point of the upper atmosphere directly over the station of the needle, EW and PM the parallel of

latitude and meridian traced through this point, S the point of the photosphere directly underneath the sun, at a certain hour in the forenoon, AB the parallel of latitude followed by the sun in its diurnal motion, and SP the arc of a great circle followed by the electric current flowing from S to P. Let this current be decomposed into the two equivalent currents P*d* and P*h*, the one lying in the meridian MP, and the other in the parallel of latitude EW. The variations of the current P*d*, as the point S moves westward along the parallel AB, serve to explain the principal westerly and easterly movement of the needle, while those of the current P*h* serve to explain the variations of the horizontal force during the same hours To understand the effect of a current in its action on a magnetic needle, we have only to recall to mind Ampère's rule, viz., to suppose ourselves lying along the current circulating from the head toward the feet, and facing the needle, then the north end will move toward the right; or we may, in the present case, suppose ourselves to be standing, (in a vertical position,) on the line of the current, and to be looking toward the needle from the side from which the current flows, then the *circular* action of the current on the north end of the needle will be in the direction of the motion of the hands of a watch. It follows that when the meridional current in the upper atmosphere is directed toward the North, the needle will be impelled toward the West, and when it is directed toward the South, it will be impelled toward the East. It is manifest that the meridional current P*d* will increase until the hour of noon, and after that decrease, and hence that there should be a westerly movement during the forenoon, and an easterly during the afternoon. The explanation of the fact that the turning point falls an hour or two after mid-day will hereafter present itself. If we suppose APB to represent the azimuth circle which crosses the meridian at P under an angle of 90° (corresponding on the photosphere to the prime vertical in the heavens) early in the morning when the sun is to the east of A, the component meridional current will be directed toward the south; but as the sun, or rather the point of excitement underneath it, moves westward this current will decrease, and vanish altogether when the sun is over A, and hence from the cause under consideration the motion should be westward. After the sun has passed B, the meridional current will again be directed toward the south, but it will now be on the increase, and hence the easterly motion should continue. The reason of the morning easterly movement will appear in the sequel.

The similar nocturnal movements of the needle may be explained in a similar manner, if we suppose that there is another point of excitement on the photosphere from which electric cur-

rents flow in all directions, diametrically opposite to the point directly under the sun. If the electric excitement of the upper atmosphere by the sun be indeed a consequence of the propagation of a vibratory motion (or impulse) by ethereal waves, then I conceive that the concentration of the separate currents (individual pulses) at the point diametrically opposite the sun would give rise to a certain increase of excitement, and to currents of a certain intensity flowing in every direction outward from this point along the surface of the atmosphere. The resistance experienced by the individual currents flowing from the point under the sun, together with the diminution from the very law of propagation, should cause the intensity of the electric excitement at this second point to be less than at the first; and accordingly the needle should be less effected at night by the passage of this point along the upper atmosphere than during the day by the passage of the point directly underneath the sun. If the entire mass of the earth should be partially transparent to the wave or force propagated from the sun, then a certain degree of excitement would be produced, at the point diametrically opposite to the sun, by the sun's direct action.

I infer from certain theoretical considerations, on physical grounds, that the radial current proceeding from the two points of maximum electric excitement should be attended with transverse impulses (or circular currents) of a feebler intensity. Such transverse currents, if they be directed from right to left (east to west side), would tend to deflect the needle to the east early in the morning, also to prolong the westerly movement after midday, and to diminish the motion toward the east in the afternoon. Their effects would therefore correspond with phenomena which really occur, and they seem to supply what is wanting in the radial currents to complete the explanation of the diurnal movement. Still there is another set of currents, to which allusion has been made (p. 186), viz. the ecliptic currents, which, as we shall see, generally tend to produce similar effects; and as the fact of the existence and very decided action of these currents can be conclusively established, we must conclude that if the supposed transverse currents really exist, they only conspire in general with the ecliptic currents to produce similar effects, in disturbing the declination. I shall therefore not undertake the explanation in detail of the action of the transverse currents, but content myself with simply pointing out, in each instance, the nature of this action.

I have hitherto regarded the point of the photosphere directly under the sun, as the only point electrically excited by the sun's action, and from which the currents flow; but on theoretical grounds other points upon which the solar emanations fall should

be excited in a similar manner and send off radial, and possibly feebler transverse currents. There is however, one possible conception that might be formed of the nature of the sun's action, which confines the radial currents entirely to the great circles diverging from the point underneath the sun. This is that these currents have their origin partly in the polarization of the electric rays by refraction; the vibration of such a polarized ray would be confined to the plane of incidence and would be attended with two impulses which would be propagated in opposite directions. A longitudinal impulse propagated along the ray proceeding from the sun, by its obliquity to the surface of the atmosphere would give rise to a current flowing away from the sun. But such considerations are foreign to the present inquiry. Taking up now the idea of a general electric excitement of the upper atmosphere which receives the sun's rays, we are to consider the various points of the parallel of latitude followed by the sun, (AB, Fig. 2,) as acquiring more and more electric intensity, (that is more and more intensity of electric vibration,) as the sun approaches them, and as declining in intensity after the sun has passed to the west of them. It is not reasonable to suppose, however, that the diminution of intensity should begin at the moment of the sun's passage through the zenith of the point, for any current excited by the sun's impulse must decline gradually. An hour after this passage, if the sun were to cease to act the moment it reached the zenith, a certain portion of the current then in existence would still be circulating; and hence it follows that the current flowing from the point in question will continue to increase until the diminution of the sun's impulse overbalances the portion of the current that remains undestroyed by the resistances. The current that follows the meridian of the station of the needle (coming from M, Fig. 2,) should then increase until a certain time after noon, and therefore the declination not attain its maximum at the hour of noon. Later in the afternoon the points that lie to the west of the meridian come into most efficient action, and the needle accordingly moves toward the east. Toward sundown the points of maximum electric excitement fall to the west of the prime vertical (PB), and their meridional components are directed toward the south; the easterly motion will therefore continue. During the latter part of the night the points that lie to the east of the prime vertical (PA) acquire a greater intensity of excitation from hour to hour, but as the obliquity of the current that proceeds from the shifting point of maximum excitement, to the prime vertical, increases, the tendency will be to a westerly deflection. This will be diminished by reason of the greater proximity of the points immediately to the east of the prime vertical. In fact, in the summer

months, as the sun's action is more in advance on the parallels of latitude to the north, and as the currents from these are nearer and inclined under a larger angle to the prime vertical than those from the parallel under the sun, it may very well happen that the needle will be deflected toward the east. We must take into account the fact that as a line of given excitement draws near the station, the currents from the points of it nearly east of the station will experience a greater proportional increase of intensity than those farther south; because of the law of divergence of the individual currents, and the law of diminution of each individual current from the effect of resistances as the distance traversed increases. Early in the forenoon the determining points fall to the west of the prime vertical (PA), and a decided westward movement should obtain.

I shall show in another connection (see p. 202) that the ecliptic currents play an important part in the forenoon; tending to produce an easterly movement in certain morning hours, (in the summer,) and subsequently a displacement toward the west. The oscillation of the needle first to the east and then to the west, during the forenoon, is a result of the joint action of both systems of currents.

We have hitherto regarded the two component currents which, by their changes of intensity and direction, determine the variations of the declination and horizontal force, as lying, respectively, in the geographical meridian, and in the line crossing the meridian at right angles. Strictly speaking, the primary currents should be decomposed into two currents following the magnetic meridian and traversing this meridian perpendicularly. In this region of the earth the two meridians are inclined to each other under a small angle. For the sake of simplicity I shall continue to consider them as coincident. It will be easy in any special case, to allow for the effect of their actual inclination.

Annual Variations.

Under this head are comprehended all the inequalities of declination, and of diurnal variation of declination, whose period is either an entire year or any fraction of a year. The laws of all such inequalities may be deduced from the following table, taken from Vol. II of the Toronto Observations. (See next page.)

The most conspicuous inequality is that of the diurnal variation. The diurnal range changes materially from one season to another. Thus, in the year 1846, the mean daily range during the months of January, February, November and December was 6′·33; during March, April, September and October 9′·21; and during May, June, July and August 12′·27. The mean for the whole year was 9′·27. It is therefore greatest in the summer, least in the winter, and has an intermediate value in spring and

TABLE I.

Showing the Mean (West) Declination at Toronto at every Observation Hour in every month of the year 1846, *derived from three years of hourly Observations.*

Toronto Time. Astronomical Reckoning.		Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		1°+	1°+	1°+	1°+	1°+	1°+	1°+	1°+	1°+	1°+	1°+	1°+
H.	M.												
12	3	30′31	30′63	30′07	30′21	30′25	30′40	29′62	30′23	30′72	30′67	30′08	28′96
13	3	30·33	30·76	30·17	29·85	31·30	30·94	29·88	30·74	30·03	29·72	31·08	29·23
14	3	29·64	30·65	29·99	30·67	31·48	31·10	30·60	30·75	30·06	29·17	30·95	29·75
15	3	29·74	30·00	30·05	30·07	30·78	31·27	30·88	30·35	29·64	29·60	30·14	29·27
16	3	28·98	30·20	29·94	29·43	30·00	30·36	30·49	30·46	28·75	29·05	30·30	29·38
17	3	29·62	29·28	29·77	28·87	28·26	28·36	28·67	29·09	28·66	28·71	29·91	29·59
18	3	29·43	29·26	29·28	28·13	26·71	25·93	26·02	26·36	29·53	29·37	29·59	30·83
19	3	29·07	28·93	28·63	27·81	25·68	25·13	24·54	24·19	30·20	29·56	29·21	30·14
20	3	28·15	28·42	27·50	27·80	25·71	25·22	24·48	23·97	28·40	28·58	28·21	28·95
21	3	28·33	29·47	27·15	28·35	27·88	26·73	25·98	26·20	29·58	28·71	28·36	28·53
22	3	29·46	30·35	28·97	30·57	31·29	29·38	28·99	30·56	32·34	30·02	29·78	28·89
23	3	31·35	32·18	32·32	33·83	35·08	32·96	32·80	34·25	35·00	32·72	31·87	30·37
0	3	33·19	33·80	34·95	36·49	37·01	35·62	35·58	37·43	38·18	34·82	33·91	31·98
1	3	33·76	34·42	36·51	37·81	37·77	37·32	37·05	38·86	37·83	37·73	37·43	35·59
2	3	33·38	34·10	36·54	37·68	37·22	37·30	37·15	38·31	37·42	35·18	35·02	33·54
3	3	32·76	33·21	35·84	36·91	35·96	36·49	36·43	36·44	35·45	34·02	33·95	32·72
4	3	31·60	32·38	34·49	35·17	34·13	35·12	35·15	34·48	33·33	33·23	33·34	31·99
5	3	30·82	31·98	33·48	33·08	32·50	33·17	33·23	32·70	31·41	32·57	32·52	31·22
6	3	30·48	31·30	32·17	31·93	31·49	31·82	32·05	30·80	30·29	30·67	31·47	30·36
7	3	30·00	30·94	31·32	30·93	31·40	31·11	31·43	30·88	30·73	31·33	29·98	29·57
8	3	28·81	29·93	30·79	30·79	31·47	31·14	31·16	30·56	30·16	30·43	30·12	28·90
9	3	28·92	29·53	29·60	30·03	31·30	30·34	31·08	28·30	30·40	29·61	28·57	28·77
10	3	29·57	29·97	29·98	30·77	30·59	30·31	29·52	29·52	29·70	29·70	29·08	28·31
11	3	29·56	30·16	29·14	29·88	29·98	30·21	29·41	29·51	30·62	30·21	29·42	28·54
Means.		30·30	30·91	31·19	31·54	31·47	31·16	30·92	31·04	31·60	31·06	31·01	30·22

The corrections have been applied for the secular change, reducing to the mean epoch, July 1st, 1846.

autumn. The peculiarities of the mean diurnal variation in the opposite seasons of summer and winter, are exhibited in the following curves. (Figs. 3 and 4.)

Besides the difference in the amount of the daily range it may be noted that the diminution of declination in the morning hours is much greater in summer than in winter, and is comprised within a shorter interval of time; also that the turning point, from the easterly to the westerly motion occurs earlier in summer than in winter. The greater diurnal range in summer is a consequence of the *relative* depression of the morning minimum, and elevation of the afternoon maximum. (See also Table I.) The depression is greater than the elevation. The morning minimum is 3′·40 lower in June than in December, while the afternoon maximum is 1′·74 higher in June than in December. At the hour of noon the declination is 3′·64 greater in June than in December.

It will readily be seen that the needle ought to decline farther to the east in the morning hours in summer than in winter, when we reflect that the points of maximum excitation at these hours

Diurnal Variation of the Declination, Toronto.

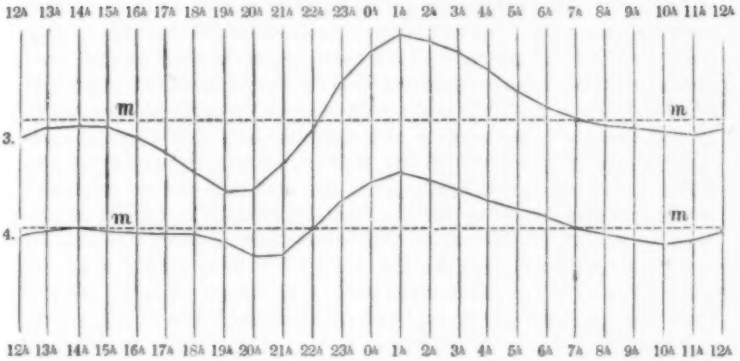
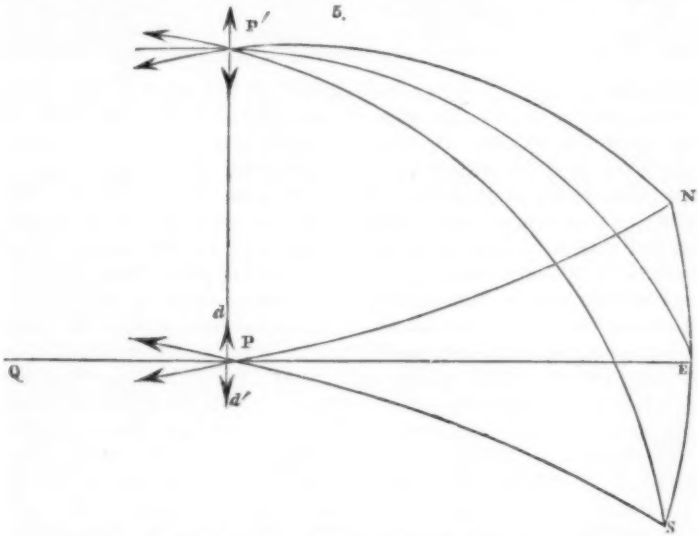


Fig. 3. *April to August, inclusive.*—Fig. 4. *October to February, inclusive. 0h answers to noon. Scale 0in·25 to 1′ of arc. Ascending curve is increasing declination (West), descending curve decreasing declination: m m, line of Mean Declination.*

lie to the east of the prime vertical and to the north of the equator in summer, and to the west of the prime vertical and south of the equator in winter. On the other hand about the hour of noon, when the points in question are in the vicinity of the meridian, the west declination ought to be greater in summer than in winter. We shall see that the ecliptic currents conspire with the radial in producing a relative depression in the morning. In like manner each system of currents tends to make the turning point, from easterly to westerly motion, occur earlier in summer than in the winter. To consider now the action of the radial currents alone; we have to observe that on all the parallels of latitude to the north of the equator the sun has a greater altitude at a given hour in the forenoon, in the summer than in the winter: hence the points in those parallels, which lie to the west of the prime vertical, have a higher electric intensity in the summer. Thus, at Toronto, the turning point in December is 9 A. M., in June 7 A. M.; now 9 A. M. in December is 1½ hours after sunrise, and in June 4½ hours. The sun's altitude also increases more rapidly in June than in December.

There is another annual variation, which has recently been brought to light by Colonel Sabine. It consists in this: If a comparison is made of the values of the declination at the hour of 7 to 8 A. M. among themselves, it appears that "at the northern solstice the north end of the magnet is at the eastern extreme of a periodical movement, which apart from, and independently of, all other movements whatsoever, has its opposite or western extreme at the period of the southern solstice, and returns into itself at the next return of the northern solstice. It is therefore strictly an *Annual Variation*, or a variation whose period is a year. Its amount is, at Toronto, about five minutes of declin-

ation." What is remarkable, we are also assured that an annual variation of the declination at the same hour of 7 to 8 A. M., "almost precisely similar in character and amount," obtains at Hobarton, which is nearly diametrically opposite to Toronto, and also at the two intertropical stations of St. Helena and the Cape of Good Hope, and is probably therefore a general phenomenon. It will be seen upon a little examination that it is a simple consequence of the shifting of the position of the radial current proceeding from the point underneath the sun, which may be taken as the representative of all the radial currents in action at the hour in question. To show this let us first suppose the station to be on the equator. At the hour of 7 to 8 o'clock A. M. the point of maximum excitement will be on the 6 o'clock hour circle, as it lags an hour or two behind the sun. (See p. 192.) Now let EQ, Fig. 5, be the equator, as traced on the photosphere, P



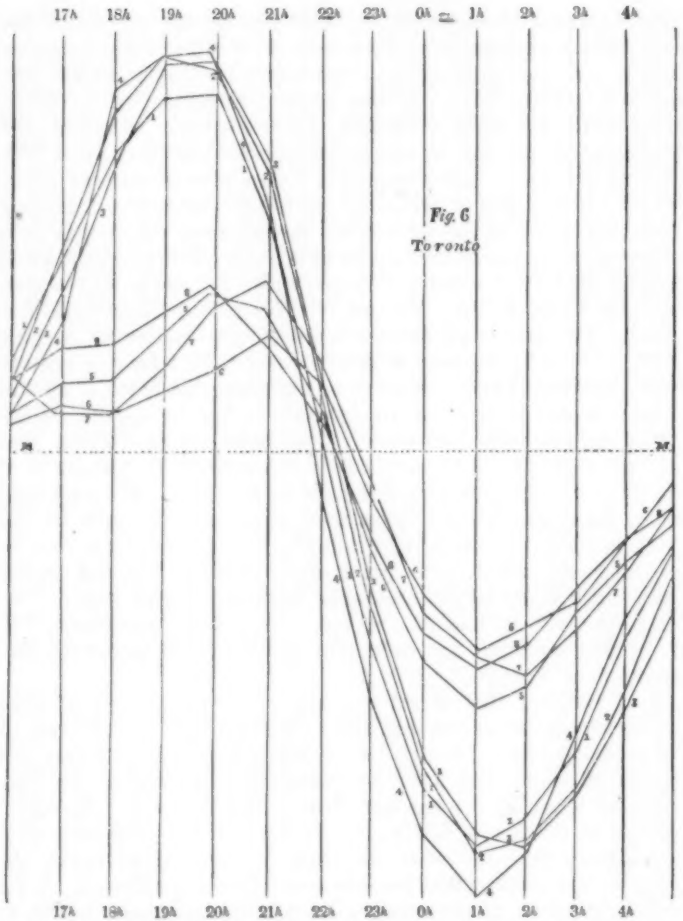
the zenith of the station of the needle, N the position of the point of highest intensity at the time of the northern solstice, on the 6 o'clock hour circle, and S the same point at the time of the southern solstice. NPE=EPS=23½°. The meridional component of the current along NP will be directed toward the south, that of the current SP toward the north. The former will displace the north end of the needle toward the east, the latter toward the west by an equal amount. (A transverse current, in the present instance, could have no effect, since it would be equally inclined to the meridian at the two solstices, and solicit the needle with the same force toward the east.)

Next suppose Toronto (N. lat. 43½°) to be the station of the needle, and represent it by P′ in Fig. 5. P′E will be the prime vertical on the photosphere; and P′EQ = 43½°, P′E = 90°, and NE = SE = 23½°. From which we have, NP′ = 74° 5′, NP′E = 17° 30′, SP′E = 17° 30′, SP′ = 105° 55′. Current NP′ impels the north end of the needle toward the East, and SP′ toward the West. The meridional component of current NP′ = NP′ sin NP′E; that of SP′ = SP′ sin SP′E; hence the deflecting force at Toronto in the interval of the solstices, is to that at a station on the equator in the ratio of NP′ sin NP′E + SP′ sin SP′E to 2 NP sin 23½°.* Going through with the calculation we find the ratio to be 0·78. NP′ sin NP′E = 0·312,† SP′ sin SP′E = 0·312. The horizontal force at Toronto is to that at the equator nearly as 5 to 9; dividing 0·78 by $\frac{5}{9}$ we obtain 1·40 as the ratio of *deflection* at the two stations, or the deflection being 5′ at Toronto it should be 3′·57 at the equator. I find by calculation, allowing for the west declination of the needle at St. Helena, that the deflection should be very nearly the same at St. Helena as at the equator. At Hobarton it should be about 4′. We may conclude, therefore, that the deflection, so far as it depends on the radial currents, is everywhere in the same direction, from the one solstice to the other, and that it should vary in amount at the four British Colonial Observatories between 5′ and 3′·6. The diagrams given by Colonel Sabine, (Toronto Observations, Vol. II, p. 20,) represent the deflection as about 0′·5 less at St. Helena than at Toronto.

It is obvious that if we compare any two periods of time equally distant from the equinox, we shall have a deflection of the same character, though less in amount than in the case just considered, since the north and south declinations of the sun, (NE and SE, Fig. 5,) are less than at the solstices. Since the change of the sun's declination is very slow before and after the solstice, the amount of the deflection should be nearly the same for the months that precede and follow the solstices. This fact as the result of observation is exhibited to the eye in Fig. 6, (which is a transcript of Fig. 1, p. 20, Vol. II, of Toronto Observations). From the cause now under consideration the same effect should occur at the hours following 7 to 8 A. M.; but it should be less in amount from hour to hour, because the angle NP′S is less and less as the arc NS is carried farther to the west by the diurnal revolution. This fact is also shown in the dia-

* By the arcs NP′, SP′, NP, is meant the force of the currents proceeding from N and S to P and P′.

† Current along $NP' = \frac{1}{\sin NP'}$. The effect of the currents proceeding from any point, as N, varies with the distance by reason of the divergence of the individual currents, which follow arcs of great circles, because of the effect of resistances upon the individual currents, and doubtless also from the very nature of the propagation. The intensity of a galvanic current varies inversely as the square root of the length of the wire traversed.



These curves show the deviations of the declination, at the specified hours, in the months named, from the mean declination in all the months and at all the hours, represented by the horizontal line MM. *An ordinate lying above* MM *shows that the declination (West) at that hour is less than the mean, one lying below that it is greater than the mean.* 1, *May*; 2, *June*; 3, *July*; 4, *August*; 5, *November*; 6, *December*; 7, *January*; 8, *February*. *Scale* 0in·5 *to* 1′ *of arc.*

gram, (Fig. 6). It should disappear at noon, and recur in the afternoon, but we shall soon see that antagonistic causes come into operation in the afternoon, which prevent the same result from being realized. We shall see also that the deflection at 7 to 8 A. M., and the forenoon hours generally, in passing from the summer to the winter months, is not wholly due to the shifting of the radial current from the north to the south side of the prime vertical, as we have thus far considered it.

We must now direct attention to the existence of another form of electric current in the photosphere of the earth, already briefly alluded to, from which several interesting effects ensue. This is a current, or rather system of currents, induced by the sun's magnetic action on the photosphere, and running in a direction parallel or nearly so to the ecliptic and from east to west. I conceive them to be developed by the inductive action (the simple propagation of an impulse probably) of currents traversing the sun's surface in a direction parallel, or nearly parallel to his equator. The physical theory of their excitation does not fall within our present inquiry. The following discussion will, I think, serve completely to establish the fact of their existence. To have a clear conception of their diurnal and annual change of position, we may regard them (or at least those which originate in the lower latitudes) as represented by a single current followiug the direction of the ecliptic traced on the earth, and observe that this is carried around with the sun during the day; and at a given hour of the day goes through in the course of a year the same changes of position that it does during a day. It is also to be observed that the force of this current will be the greatest at or near the point directly underneath the sun. At either equinox, and at the hour of noon, this current will be inclined $23\frac{1}{2}°$ to the meridian of the station; at the vernal equinox passing from the north to the south side of the equator, and at the autumnal equinox from the south to the north side. The meridional component of this current will then be directed from north to south at the vernal and from south to north at the autumnal equinox. The north end of the needle ought therefore, to stand farther to the west at the autumnal than at the vernal equinox, at the hour of noon and thereabouts, at all stations. In fact there is an excess at Toronto, at noon, of 3′·23.* (See Table I.) In what precedes I have only considered the action of the ecliptic currents near the equator. In point of fact, the sun acts upon the high as well as the low latitudes, and develops at each point of its action a current which *sets out* in a direction parallel to the ecliptic and follows the course of a great circle. The more northerly currents may in general be approximately represented by a single current passing through the zenith of the station.† Throughout the year,

* This inequality of declination, which has its positive maximum at the autumnal and negative maximum at the vernal equinox, and is zero at the solstices, does not appear hitherto to have been noticed.

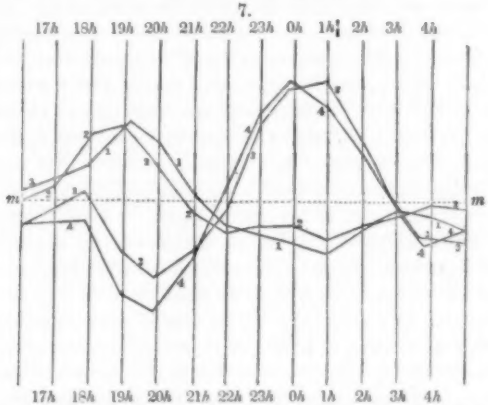
† More correctly by a single current originating in about the latitude 45°. The station is supposed in the text to be in a high northern or southern latitude (as Toronto). So long as we are only attempting to explain the laws of the phenomena it is not important that we should know the precise starting point of this representative current. It will at any given hour be shifting its position in the same direction, from whatever point in the higher latitudes it be supposed to issue. It is to be observed that, other things being the same, the effect of a current will be the greatest when it passes through the zenith of the station.

the current developed within the Torrid Zone (or rather within a few degrees of the ecliptic) may be represented by a single current following the course of the ecliptic traced on the earth's photosphere. At the equinoxes the northerly currents will cross the meridian at noon, under larger angles than this single ecliptic current, but their tendency will be the same in the inequality just considered. Let us endeavor to obtain a general conception of the entire system of currents now under consideration. *At the solstices* the currents will everywhere, at the outset be parallel to the equator, and the circle traced through the various points from which they proceed at any one instant, will be a meridian and correspond to the solstitial colure. The entire system of currents will pass through the pole of this circle, lying on the equator 90° to the west of the circle. As the earth rotates the circle of excitement with its pole will be carried toward the west, and the inclination of each of these currents to the meridian of any particular station will vary continually. The currents in question will also pass through the other pole, 90° to the east of the circle on which they originate, but they will flow from this pole toward the circle, and from the circle toward the other pole. To the west of the circle they are *leading* currents, to the east of it *following* currents. The two poles will in all cases be diametrically opposite to each other, and on the ecliptic. The starting point of the current that passes through the zenith of the station also varies continually. At 6 A. M. and 6 P. M. this current issues at the pole, at noon its starting point is in the zenith of the station. *At the equinoxes* the circle of excitement will coincide with the circle of latitude (that is circle through the pole of the ecliptic) which passes through the equinoctial points. The currents will set out perpendicularly to this circle and all meet at its pole. This pole will, at the autumnal equinox, lie in the northern Tropic, and move along it toward the west. At the vernal equinox the pole will follow the course of the southern Tropic. During the year it will move along the ecliptic from west to east, keeping always 90° behind the sun. It will therefore pass gradually from one tropic to the other, as the sun does, but be on one of the tropics when the sun is on the equator, and vice-versa. The two poles, or points of concentration of the currents, will always be on opposite sides of the equator, and in the same latitude. At 6 A. M. and 6 P. M., on the day of the autumnal equinox, the current which traverses the zenith of the station originates at a point on its meridian $23\frac{1}{2}°$ beyond the pole; at noon at a point a few degrees to the south and east of the station, and crosses the meridian under an angle of 73°. At the same hours on the day of the vernal equinox, the current in question originates at the point on the meridian $23\frac{1}{2}°$ on this side of the pole; at noon a few degrees to the south and west of the station, and deviates 73° from the meridian.

At the Solstices, at the hours of noon and midnight, the ecliptic current will have no effect on the declination, since it will cross the meridian of the station perpendicularly. But at 6 A. M. and thereabouts it will tend to produce a deflection of the needle from East to West, in the interval from the northern to the southern solstice; and this in both hemispheres. For at the northern solstice, it will, at this hour, cross the meridian under an angle of $66\frac{1}{2}°$, and tend from north to south, but at the southern solstice it will cross the meridian under the same angle from south to north. The extratropical currents are at this hour more oblique to the meridian, than the intertropical (just represented by a single ecliptic current); but their representative current will have the same inclination to the meridian at the one solstice as at the other, passing from N. of E. to S. of W. at the northern solstice, and S. of E. to N. of W. at the southern solstice. These currents will therefore conspire with those that originate between the tropics in producing an annual oscillation of the needle, from the one solstice to the other. The observed oscillation of about 5′, at 7 to 8 A. M. (see p. 195), is therefore to be regarded as the sum of the effects of the entire system of radial and ecliptic currents. It is to be observed that each set of currents has traversed an arc of nearly 90° before it comes into operation at this hour. The same effect, though less in amount, should occur at each of the successive forenoon hours. In the afternoon the tendency is everywhere reversed; the ecliptic currents are therefore now antagonistic to the radial (see p. 198), and tend to counteract these currents in their tendency to produce the same species of oscillation as in the morning hours. In this way we may explain the comparatively small oscillation that occurs toward 6 P. M. (a fact which is conspicuously indicated by the curves of Fig. 6.) Toward mid-day, and afterwards, the stronger meridional currents, when the sun is at the nearer solstice, has the effect to make the west declination in both hemispheres, greater at the northern than at the southern solstice. We shall have corresponding results if we compare any two months equally distant from the equinox. At intertropical stations they will also be similar if the comparison is made between any two months, on opposite sides of the equinox, at which the sun is on the same side of the zenith of the place. (This qualification is made only with respect to the mid-day relative positions, which are due chiefly to the radial currents.) The same relative positions of the north end of the needle, at the various hours of the day, should in fact obtain on the comparison of two periods very near the equinox, as, the interval from Sept. 1 to 15 with that from Oct. 1 to 15. This appears in the following curves, constructed from the observations made at St. Helena. No. 2 answers to the former interval, and No. 3 to the latter. The ordinates show the deviations

of the declination at the several hours from the means for the year at the same hours. An ordinate lying above *m m* shows that the needle is at that hour to the east of its mean annual position at that hour, and an ordinate lying below *m m* shows that the needle is to the west of its mean position.

7.



1, *Aug.* 16 *to* 31; 2, *Sept.* 1 *to* 15; 3, *Oct.* 1 *to* 15; 4, *Oct.* 16 *to* 31.

The ecliptic currents play an important part in modifying the diurnal variations. Let us first see what should be their effects in the northern hemisphere at the time of the *summer solstice*. If we follow the solstitial colure to the point $23\frac{1}{2}^\circ$ beyond the pole, we reach the last point excited; this will move from east to west along the polar circle. I find that about $1\frac{3}{5}$ hours before 6 A. M. the current from this point will pass through the zenith of Toronto, crossing the meridian under an angle of 34°. At midnight it will cross the meridian perpendicularly, $23\frac{1}{2}^\circ$ south of the pole. Soon after midnight the currents from the various points of the arc connecting the point in question with the pole, cross the meridian under a very large angle and far to the north, and they should have but little effect; but as their angle of inclination to the meridian decreases there will be a tendency to an easterly displacement, which will go on increasing up to the hour of $4^h\,20^m$ A. M. The points of meridian passage of the currents in question will now, some of them fall to the south of the zenith, until finally at 6 A. M. these currents will all pass through the point of intersection of the meridian and equator; which is now the pole of the solstitial colure. Between $4^h\,20^m$ and 6 A. M. their obliquity will be increased, their meridional components will be augmented, and the easterly motion should continue. The amount of the movement should be somewhat diminished by the southerly progression of the points of meridian passage of the currents. To consider now the effect of the remaining currents; it suffices to investigate the action of the currents of the northern hemisphere, since those of

the southern hemisphere cross the meridian under the same angle, but in such a direction as to afford a meridional component in the opposite direction, and being of less intensity, only tend to diminish the effect produced by the currents of the northern hemisphere, without altering its character. The ecliptic currents of the northern hemisphere, now to be considered, proceed from the various points of the solstitial colure lying between the equator and the pole. Before the hour of 6 A. M. the point of meeting of these currents will lie on the equator and to the east of the meridian of the station. The currents after intersecting at this point pass on and cross the meridian south of the equator. As the point of concentration moves westward the obliquity of the currents to the meridian, at their respective points of passage, will increase, and hence the needle will be deflected still more toward the east. After 6 A. M. the obliquity will diminish, and a tendency to a westward movement will obtain. This will be more or less diminished by the continued augmentation of the strength of the individual currents, as the circle of excitement is brought nearer to the meridian, and also by the movement northward of the points of meridian passage of the currents. The currents first considered (before 6 A. M.) will now cross the meridian farther and farther to the south, and under larger and larger angles, and will therefore unite with the others in creating a westward tendency. This tendency to a westward movement will continue until noon, and during the afternoon until 6 P. M. The actual diurnal variation of the declination, is a combination of these effects and of those already noticed, of the radial currents. The variations, as they have been determined by observation, may be ascertained by turning to Table I, and observing the comparative declinations as given for the month of June. It seems that either a tendency to a diminution of declination, produced by the radial currents, from 6 to 7 A. M., prevails slightly over the tendency to an augmentation resulting from the action of the other set of currents; or else that we must ascribe the fall of declination at this hour to the two causes of diminution just mentioned. On either view it is important to observe that the hourly change of the obliquity of these currents, to the meridian, is at its maximum at the hours of 6 A. M. and 6 P. M. (See p. 209.)

Let us pass to the epoch of the *winter solstice*. The effective currents in the morning hours, are now those of the southern hemisphere, and hence as they cross the meridian from S. of E. to N. of W., instead of from N. of E. to S. of W., the tendency of the needle at the same hours, should be in the opposite direction from that which prevails at the summer solstice: that is the declination should increase previous to 6 A. M., and afterward decrease for a time. (See Table I, December column.) There is now no tendency to a diminution in the early morning hours,

from any action of radial currents; we have already seen that the slight effect of these is the reverse at this season. In the course of the forenoon, the ecliptic currents of the northern hemisphere will come into preponderating action; because after 6 A. M. the points of meridian passage of these currents will move north, toward the zenith of the station, while those of the southern currents will decline toward the south. The radial currents of the northern hemisphere will also come into action. From both of these causes combined, the declination begins to augment before the hour of noon.

At the equinoxes the resultant of the entire set of ecliptic currents would be a single current following the course of the ecliptic traced on the photosphere, but for the fact that the currents of the two hemispheres cross the meridian under somewhat different angles, and in different points (except at the hours of 6 A. M. and 6 P. M.). *At the autumnal equinox*, before 6 A. M. the currents of the southern hemisphere cross the meridian to the north of the tropic of Cancer, and after 6 A. M. the same is true of the currents of the northern hemisphere. Previous to 6 A. M. we may represent the whole system of currents by a single one in the ecliptic, and another crossing the northern tropic, at the point of general concentration, in a direction from S. of E. to N. of W. For the sake of distinction we will call the former the *primary* and the latter the *secondary* current. After 6 A. M. the secondary current crosses the tropic in a direction from N. of E. to S. of W. Now at the earlier hours the obliquity of the secondary current to the meridian, continually, but slowly, (p. 209,) increases, and hence the needle has a slight tendency westward. The primary current now crosses the meridian from N. of E. to S. of W., and its obliquity rapidly decreases, and hence an increased tendency westward. Later than 6 A. M. the secondary current, now in the northern hemisphere, experiences a slow diminution of obliquity, while the obliquity of the primary current, which now runs from S. of E. to N. of W., rapidly increases. Both currents therefore conspire as before to urge the needle westward. To this westward tendency in the morning hours is perhaps opposed a slight tendency in the opposite direction from the action of the radial currents. The facts in the case will be seen on glancing at the September column of Table I. The movement is westward after 4 or 5 A. M., except from 7 to 8 A. M. The easterly motion at that hour may perhaps be due to the progression northward of the points of meridian passage of the currents, together with the augmentation of their individual intensities by reason of the westward movement of the circle of excitement. Later in the forenoon the shifting position of the ecliptic currents, both primary and secondary, tends to keep up the increase of declination from hour to hour. At noon the declination, so far as it de-

pends on these currents, should be at its maximum. During the afternoon the primary ecliptic current becomes less and less oblique to the meridian, in a direction, S. of E. to N. of W., and hence the needle tends to shift its position toward the east. The secondary current is opposed to this; but its effect will be weakened in the latter part of the afternoon, by the progression southward of the point of meridian passage of the current. The primary ecliptic and the radial currents, therefore, unitedly impel the needle toward the east, while the secondary current urges it in the opposite direction. The hourly change, so far as it is due to the primary current, will be greatest early in the forenoon, and late in the afternoon, and least at noon; so far as it is due to the secondary current, it will be greatest toward mid-day, and least at 6 A. M. and 6 P. M. From the effect of both currents it should be greatest, a short time after the middle of the forenoon. It should be less at the middle of the afternoon, because the secondary current is now opposed to the radial. Table II. (p. 208) gives the hourly change from 9 to 10 A. M. in September 3′·25, and from 2 to 3 P. M., 1′·82.

At *the vernal equinox* the point of concentration of the ecliptic currents is on the Southern Tropic; the secondary current, previous to 6 A. M. will be much less oblique to the meridian, and after that hour much more oblique than at the Autumnal Equinox. The primary current will now, in the earlier hours, run from S. of E. to N. of W.; its obliquity will diminish from hour to hour, and hence there will be a tendency toward the east. After 6 A. M. the current goes from N. of E. to S. of W., and its obliquity increases so that the tendency continues to be the same. In the present case the secondary current is opposed to the primary, but its first effects are slight; for two or three reasons, it is differential in its character, and therefore comparatively feeble, is remote from the zenith, and its hourly change of position is the least possible in the morning hours. On turning to Table I, and examining the column for March, it will be seen that the declination steadily decreases from 3 A. M. to 9 A. M. After this hour the radial and secondary prevail over the primary current, and the deflection is toward the west. In the afternoon the action of the primary current is reversed, while that of the secondary remains the same. We have therefore the primary and secondary ecliptic currents both acting in opposition to the radial and checking the movement toward the East. The amount of the displacement of the needle should therefore be greater in the forenoon than in the afternoon. The actual deflection from 6 A. M. to noon is 5′·67 (Table I), and from noon to 6 P. M. is 2′·78. At the autumnal equinox the three currents act together in the forenoon; and the deflection is 8′·65. In the afternoon the secondary current is opposed to the other two, but its principal effects both in the morning and afternoon lie within three or

four hours of noon, because it is then that its position changes most rapidly, (p. 209). At the same hours the primary current is in its position of minimum action. Table I. gives for the deflection in September between 8 A. M. and 12 M. 9′·78, and between 12 M. and 4 P. M. 4′·85.

At other periods of the year the general character of the effects of the currents may be readily ascertained if we reflect that in the summer months, the currents of the Northern Hemisphere prevail throughout the day, while in the winter months the currents of the Southern Hemisphere come into prevailing action in the morning hours, from 4 or 5 A. M. to 8 or 9 A. M.; and that toward the equinoxes the effect of the primary ecliptic current is greater than at other seasons. We see therefore that the curves for the summer months should resemble that for the day of the summer solstice, and the curves for the winter months that for the day of the winter solstice; and that the curves for March and September should be somewhat different. (See Fig. 6, also Hobarton Observations, Vol. I, p. 34.) The change from a westward to an eastward tendency at the hour of 6 A. M. in the winter months, is observable in the curves 5, 6, 7, 8, of Fig. 6. Previous to 5 A. M. there is a slight eastward tendency, except in the curve for January. This I ascribe to the easterly deflection that follows the meridian passage of the point of maximum electric excitement diametrically opposite the sun. This point should be particularly effective in the winter, because its declination is north. The opposite change of tendency, viz., from east to west, at 6 A. M. is to be seen in the curves 1, 2, 3, 4. That the westerly motion does not actually begin at that hour I suppose to be owing to the action of the radial currents, which tend to urge the needle toward the east early in the forenoon. The greater part of the movement in this direction previous to 6 A. M., is doubtless attributable to the same action of the radial currents.

If we compare any one curve with the others, we find that the differences and correspondences which subsist, are in almost every instance such as the theory calls for. Thus, at 6 A. M. the needle should stand farther to the east in June than in May or July, because the ecliptic currents are more oblique to the meridian; also the position should be nearly the same at that hour, in May and July, since the obliquity of the currents is nearly the same. The more easterly position of the needle, at 6 A. M., in August than in June would seem to be an exception, but it is to be observed that the points of meridian passage of the ecliptic currents, at the hour in question, are almost twice as near the zenith of the station (Toronto) in August as in June, and it is possible that this may over-balance the diminution of the obliquity of the currents. Again, from the predominance of the currents of the Southern Hemisphere, there should be an especial tendency to a westward displacement of the needle, at the

hour of 6 A. M. in December; but the tendency should be approximately the same in November, December and January. In February it should be less, because the preponderance of the currents of the Southern Hemisphere is diminished, and the primary ecliptic current is less oblique to the meridian. If we pass to the hour of noon, the declination is greater in August than in June because of the greater obliquity of the ecliptic to the meridian; —the increase of this obliquity prevailing over the diminution of the action of the radial currents. In the winter months the mid-day declination should be the least in December, because the tendency of the radial currents to deflect the needle toward the west is then at its minimum. In November the declination at noon should be greater than in January or February, because the ecliptic crosses the meridian in November in a direction from S. of E. to N. of W., and in January and February from N. of E. to S. of W.

It is a consequence of our theory of the combined action of radial and ecliptic currents, that in the middle of the day the declination should be greater at the autumnal than at the vernal equinox. This fact has already been noticed (p. 199). It follows also that the declination should be nearly the same both at 6 A. M. and 6 P.M. at the equinoxes. The actual difference at 6 A. M. is only $0'{\cdot}25$; at 6 P. M. the declination is $1'{\cdot}9$ greater at the vernal than at the autumnal equinox. This excess of $1'{\cdot}9$ is probably in part due to the irregular disturbances, so called, for these are much greater at the autumnal than at the vernal equinox, and at 6 P. M. and for several hours after the easterly disturbance preponderates over the westerly. It also may be in part attributable to the more northerly position, in the latter part of the afternoon, of the point of meridian passage of the secondary ecliptic current. Another consequence of our theory is that the increase of declination from 6 A. M. to noon should be greater at the autumnal than at the vernal equinox; because at the former the three currents are combined in their action, whereas at the latter the primary current is opposed to the other two. The actual numbers are $8'{\cdot}65$ and $5'{\cdot}67$. Let x= rad. + sec. currents (or rather their effect), and y= primary current; then $x+y=8'{\cdot}65$, $x-y=5'{\cdot}67$, $x=7'{\cdot}16$, $y=1'{\cdot}49$. We have an opportunity of verifying this determination of the effect of the primary current. The difference between the declination at noon at the equinoxes must be very nearly equal to twice the effect of the primary current at noon. The amount of this difference is $3'{\cdot}23$, and the half of it is $1'{\cdot}61$ which differs from $1'{\cdot}49$ by $0'{\cdot}12$. The afternoon movement ought also to be greater at the autumnal than at the vernal equinox, for at the former the radial and primary currents are opposed to the secondary, while at the latter the radial is opposed to the secondary and primary currents. The numbers which observation gives are $7'{\cdot}89$ and $2'{\cdot}78$. $7'{\cdot}89-1'{\cdot}49=6'{\cdot}40$= rad. − sec.; $2'{\cdot}78+1'{\cdot}49=4'{\cdot}27$=rad. − sec. With Table II, we get the results, $4'{\cdot}63$, $4'{\cdot}38$.

If we make a comparison between the hourly variations at the equinoxes, toward the middle of the day, similar differences ought to obtain. We have, therefore, an *inequality of hourly change of declination*, which has its maximum positive value at the autumnal and its maximum negative value at the vernal equinox.

At the summer solstice all the ecliptic currents tend to deflect the needle in the same direction, as they shift their position at a given hour; and in the forenoon they have the same tendency as the radial currents, in the afternoon the opposite tendency. Taking the numbers given for June (Table II.) we have $x+y=12'{\cdot}34$, $x-y=6'{\cdot}11$, $x=9'{\cdot}22$, and $y=3'{\cdot}12$. x represents the effect of the radial currents and y the effect of the ecliptic currents from 7 A. M. to 1 P. M., and also from 1 P. M. to 7 P. M. If we compare 6 A. M. to 12 M. with 12 M. to 6 P. M. we have $x=7'{\cdot}02$, $y=2'{\cdot}94$.

The ecliptic currents will have some effect in modifying the nocturnal variations of declination, but we will not enter upon the study of their more minute effects on the present occasion. The following table contains the mean hourly variations of the declination for certain hours of the day for a period of six years, from 1842 to 1848, which is half a solar period.

TABLE II.

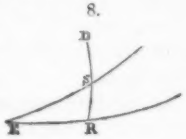
Mean hourly variations of the Declination at Toronto during a period of six years, from July, 1842, to June, 1848, inclusive.

	Jan.	Feb.	Mrch.	April	May.	June	July.	Aug.	Sept	Oct.	Nov.	Dec.
17h. to 18h.	W 0·06	0·00	E. 0·54	E. 0·94	E. 1·53	E 2·31	E. 2·01	E. 2·64	E. 1·28	W. 0·29	W. 0·02	W. 0·05
18h. to 19h.	E. 0·56	E. 0·42	E. 0·94	E. 0.44	E. 0·97	E. 1·00	E. 1·47	E 1·68	E. 1·25	E. 0·51	E. 0·60	E. 0·28
19h. to 20h.	E 1·04	E. 0·54	E 1·12	E. 0·15	E. 0·03	W 0·25	E. 0·19	W. 0·06	W. 0·94	E. 0·98	E. 0·75	E. 0·31
20h. to 21h.	E. 0·42	W. 0·84	W. 0·02	W. 1·00	W. 1·83	W. 1·55	W. 1·70	W. 2·30	W. 1·66	W. 0·18	W. 0·16	E. 0·61
21h. to 22h.	W. 1·11	W. 1·15	W. 2·05	W. 2·18	W. 3·28	W. 2·87	W. 2·85	W. 4·03	W. 3·25	W. 1·68	W. 1·52	W. 0·66
22h. to 23h.	W. 1·76	W 1·98	W. 2·93	W. 3·05	W. 3·40	W. 3·63	W 3·38	W. 3·49	W. 2·99	W 2·67	W. 2·21	W. 1·68
23h. to 0h.	W 2·16	W. 1·50	W. 2·74	W. 2·48	W. 2·18	W. 2·67	W. 2·74	W. 2·28	W. 1·92	W. 2·00	W. 1·67	W. 1·66
0h. to 1h.	W. 0·87	W. 0·23	W. 1·43	W. 1·23	W. 0·86	W. 1·37	W. 1·42	W. 0·98	E. 0·21	W. 0·43	W. 0·76	W. 0·96
1h. to 2h.	W. 0·06	0·00	W 0·01	E. 0·06	E 0·29	E. 0·02	E. 0·12	E. 0·68	E. 0·83	E. 0·24	E. 0·29	W. 0·01
2h. to 3h.	E. 0·59	E. 0·84	E. 0·67	E. 0·86	E. 1·10	E. 0·92	E. 0·84	E. 1·82	E. 1·82	E. 1·06	E. 1·11	E. 0·75
3h. to 4h.	E. 0·91	E. 0·86	E. 1·11	E. 1·66	E. 1·71	E. 1·59	E. 1·29	E. 1·86	E. 1·79	E. 0·94	E. 0·73	E. 0·98
4h. to 5h.	E. 0·84	E. 0·46	E. 1·10	E. 1·53	E. 1·70	E. 1·82	E. 1·83	E. 1·55	E. 1·26	E. 0·77	E. 0·73	E. 0·94
5h. to 6h.	E. 0·61	E. 0·72	E. 1·03	E. 1·05	E. 1·01	E. 1·10	E. 1·20	E. 1·42	E. 0·63	E. 1·19	E. 1·10	E. 0·63
6h. to 7h.	E. 0·58	E. 0·37	E. 0·80	E. 1·00	E 0·22	E. 0·66	E. 0·56	W. 0·09	E. 0·28	E. 0·07	E. 1·01	E. 0·67

The direction of movement of the north end of the needle is indicated by the letter, E or W, placed over the number.

In what precedes the law of variation of the angle included between the ecliptic and meridian, from one hour to another, or from one season to another at a given hour, has been assumed. I propose now to establish it. Let ER (Fig. 8) represent the equator, ES the ecliptic, and DSR a meridian; put ESR=S, ES=L, SER=ω=23½°. Then

8.

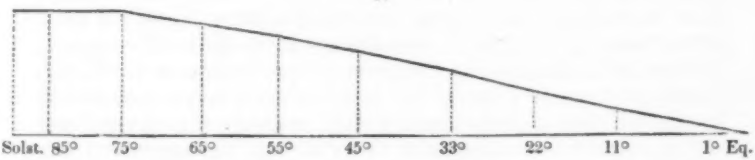


$$\text{tang S}=\frac{\cot\omega}{\cos \text{L}},\ d\,(\text{tang S})=\cot\omega\frac{\sin \text{L}\,d\,\text{L}}{\cos^2 \text{L}}=\cot\omega\frac{\text{tang L}}{\cos \text{L}}\,d\,\text{L}.$$

Thus the hourly variation of tang S is proportional to $\frac{\text{tang L}}{\cos \text{L}}$.

For L=1°, 11°, 22°, 33°, 45°, 55°, 65°, 75°, 85°, d(tang S)= ·017, ·197, ·436, ·765, 1·41, 2·50, 5·07, 14·4, 131. The corresponding values of S are, 66½, 66° 53′, 68° 3′, 69° 58′, 72° 55′, 76°, 79° 35′, 83° 35′, 87° 50′. The variations of the angles corresponding to the above variations of the tangent are as the numbers 1, 11, 22, 33, 44, 53, 60, 64, 64. If the hourly variations of the obliquity of the ecliptic current, as one or another part of the

9.



ecliptic is on the meridian, be represented by the ordinates of a curve, we have a curve of the form shown in fig 9; nearly straight toward the solstitial point and again nearly straight in the vicinity of the equinoctial point. The meridional component of the ecliptic current is proportional to cos S, and d (cos S) varies as sin S; hence the hourly change of declination resulting from the same change of the obliquity of the current is greatest at the solstitial and least at the equinoctial points. A curve showing the hourly change of declination that would result from the actual change of position of the current, would then differ from the preceding in being slightly more curved toward the solstitial point. The law of variation would be the same if we take any individual ecliptic current, instead of the primary current (so called) just considered, for this does not depend on the value of the constant, cot ω; it would also be the same for any single current taken as the representative of the ecliptic currents more remote from the equator.

It appears to me that the two laws recently made out by M. Secchi are deducible from the theory of ecliptic currents, taking

into acccount the law of variation of their angles of inclination, to the meridian, just established, but as I have only seen a meagre statement of his researches (in the Comptes Rendus) it would be premature to enter into a detailed discussion of them in the present paper.

It remains to discuss the peculiar variations of declination that occur at intertropical stations, which have been signalized by Col. Sabine. In the first volume of the Hobarton Observations we find the following statement; "the diurnal variation between the hours 2 A. M. and 10 A. M. at St. Helena correspond in respect to the direction in which the magnet moves in the months from April to August with the phenomena of the Northern Hemisphere, and from October to February with those of the Southern Hemisphere." Similar phenomena are observed at the Cape of Good Hope. The comparison between the diurnal movements at short intervals before and after the equinox is made in Fig. 7, p. 202; the same opposition of movement in the forenoon is here seen to exist very near the equinox. These curious phenomena may readily be referred to the action of the ecliptic and radial currents. When the sun is north of the equator the currents in the Northern Hemisphere predominate, and when he is south of the equator those in the Southern Hemisphere predominate. Now we have already seen (p. 202) that when the sun is considerably north of the equator the tendency of the action of the currents of the Northern Hemisphere, is to impel the needle eastward previous to 6 or 7 A. M. and afterwards toward the west, and that when he is south of the equator the tendency of the action of the currents of the Southern Hemisphere is the reverse at the same hours; and such are the actual diversities of movement that have been observed. The curves representing them for the months near the solstices, as observed at St. Helena, have the same form, and have the principal turning points at the same hours as those of Fig. 7. As the station (St. Helena) is in the Southern Hemisphere, the currents of the Southern Hemisphere, when they predominate have a more energetic action than those of the Northern Hemisphere, when in most effective action. Toward noon, (when the sun passes to the north of the zenith,) the radial currents *from within the tropics* will increase the tendency toward the east. In case the sun is north of the equator, the radial currents in question and the predominating currents from the high latitudes are opposed to each other, at that hour, but when he is south of the equator they conspire to produce an eastward movement. We see therefore that the deflection toward the west, late in the forenoon, in the former position of the sun should be less than the deflection toward the east in the latter position. In the afternoon the radial currents that come from points within the tropics will again be in opposition to the predominating extratropical currents when the sun

is considerably to the north of the equator, and in coincidence of action when the sun gets to the south of the equator. (See Fig. 7.)

Let us take now the special case represented in Fig. 7. The same effects will occur that we have just considered; they will only be less in amount. But we may also discern effects produced by the primary ecliptic current. Before and after the equinox this current crosses the meridian under a large angle, early in the morning, and by the rapid shifting of its position tends to deflect the needle more and more toward the west during the forenoon. During the afternoon the tendency is reversed. It is thus opposed to the intertropical radial current during the greater part of the day both before and after the equinox. At the earlier date, at which the sun is north of the equator, the primary current crosses the meridian early in the morning in a direction from N. of E. to S. of W.; and at the later date it runs at the same hour in a direction from S. of E. to N. of W. The needle ought therefore to have a greater west declination early in the morning after than before the equinox. That such is the fact will be seen on inspecting Fig. 7.

It is to be observed that the easterly movement of the needle from 6 to 7 A. M., when the sun is north of the equator, and westerly movement at the same hour when the sun is south of the equator, is attributed to the action of the radial currents. When the sun has a south declination the westerly tendency resulting from the action of the radial currents, from 6 to 7 or 8 A. M., should be relatively greater at St. Helena than at Toronto. Accordingly the radial may prevail over the ecliptic currents at that hour, at St. Helena, and the ecliptic over the radial at Toronto; (compare Figs. 6 and 7.)

It may be stated in general terms that the peculiar phenomena of the diurnal variation of the declination which have place at St. Helena and the Cape of Good Hope, and probably at intertropical stations generally, receive their explanation in the alternate preponderance of the extratropical currents of the Northern or Southern Hemisphere, according as the sun is north or south of the equator; together with the modifying action of the ecliptic and radial currents that are developed between the tropics.

(*To be continued.*)

ART. XX.—*Observations on the fructification of the Arachis hypogæa;* by HUGH M. NEISLER, Columbus, Geo.

IN studying our Stylosanthes a few years ago, my attention was attracted by a note in Torrey and Gray's Flora of North America, vol. i, p. 354. viz., "Mr. Bentham in a paper on the affinities of Arachis, read before the Linnæan Society in 1838, gives an account of the two kinds of flowers in Stylosanthes, and shows its affinity to Arachis, which he considers a genuine Hedysarea." I presumed that he supposed the Arachis to have two kinds of flowers, but, wishing to inform myself accurately as to his views, I mentioned the subject to Dr. Torrey in the course of our correspondence, who remarked in reply; "Mr. Bentham says, that Arachis has two kinds of flowers. Those that have all the parts, do not perfect their fruit, the ovary never ripens. The fructiferous flowers, have neither calyx, corolla, nor stamens, but consist at first of a minute ovary on a rigid stipe that arises from between two bracteoles. After fecundation, the minute ovary swells, at the same time burrows in the ground where it ripens.

On examination, I found in some specimens that had been in flower some days, in the axils of two or three of the lower leaves, minute, sessile (sometimes two or three in a kind of one-sided raceme) conical germs situated between two bracteoles; these gradually elongated themselves until reaching the earth, they penetrated beyond the reach of light, where their extremities becoming etiolated they grew succulent, enlarged and ripened their fruit. The stipe of the fruit varies much in length, in the prostrate forms of the plant from 1 to 3 or 4 inches—but in an upright variety which I cultivate, they grow 6, 12, and sometimes, even 18 inches before reaching the earth and in their growth hang around the stem like aerial rootlets. In the axils next above these fertile germs, in my specimens, I found petal-bearing flowers, which I at first (supposing Mr. Bentham's views of course to be correct) regarded as barren. But after close and repeated examinations, to my surprise, I found them in all respects perfect, and what at first sight I had thought a long peduncle which withered with the flower, proved to be a slender, tubular *calyx*, through which there was no difficulty in tracing the style to a minute conical germ, situated between two bracteoles—and in all respects identical with those in the axils below. And after examining a few plants, I succeeded in finding germs elongated to two or three inches with the marcescent calyx and corolla still *adhering to their points*, and stimulated into growth beyond a doubt by the perfect and fertilized ova. Younger plants just getting into bloom showed petal-bearing flowers in the lowest axils

and doubtless those that I first examined and which I thought achlamydeous, would have been found so, if seen a little earlier; for generally, the flower falls away entirely and is seldom found attached to the germ after withering. *The flowers of the Arachis hypogæa are all petal-bearing and all fertile.* The plant is in some respects a singular one—and I am not surprised that Mr. Bentham or any one else who had not watched it in all stages of its growth, should have fallen into error as regards its fructification.

ART. XXI.—*On certain Physical Properties of the Light of the Electric Spark, within certain Gases as seen through a Prism;* by D. ALTER, M.D., of Freeport, Pa.

IN a former communication, I noticed the peculiar character of the light produced by interrupting the galvanic circuit, between different kinds of metal. I also mentioned that several bright bands were observed in the common electric spark. I have since employed various metallic conductors, but without producing the bands corresponding with those resulting from the interrupted galvanic circuit between the same metals—the bands always remaining the same, whatever metal was employed. It then occured to me, than the bands were characteristic, not of the metals, but of the atmosphere, through which the sparks passed. To test this view, I passed the spark through various gases, in succession, and found that they were characterised by their appropriate bands, with as much distinctness, as the metals are, by the galvanic spark; e. g., I discovered in atmospheric air, one red, one orange, two green, one blue, and one indigo: while in hydrogen, I discovered one very bright red, two faint green bands, and one very faint blue. In nitrogen, one red, one orange, and two green. In chlorine, two distinct green bands, and a knot of light in the yellow and also in the blue, which I think are composed of several bands close together in each. In carbonic acid, there are, one red, three orange and two green bands. In sulphuretted hydrogen, there are red, orange and green bands. In oxygen, no bands were discovered, but the light was strong throughout the spectrum. In the other gases it is feeble, except in the bands before mentioned. The quantity of light in the red band of the spark, in hydrogen, is quite remarkable, being so great, that the spark, seen without the prism, has a very red appearance, as also in the gases compounded of hydrogen. From this, we perceive the cause of the difference in color, in the flashes of lightning—for when the electricity has a watery conductor, in much of its course, it will emit red light, but when it passes through air, the light will be white: as in the spark through that medium,

the bands are well distributed among the colors of the spectrum. The colors also, observed in the aurora borealis, probably indicate the elements involved in that phenomenon. The prism may also detect the elements in shooting stars, or luminous meteors.

Since from the preceding observations, it is evident that the electric light, whether from the interrupted galvanic current, or from the common electric machine, is principally resolved into several bright bands by the prism; and that the light, thus produced by one elementary body, differs in the number, brilliancy and situation of its bands, from every other element, so that it is immediately recognised, by mere inspection—we are led to the following inquiries. Is their such a *fluid* as electricity? or, are the phenomena, commonly reputed electrical, the result (as suggested by Prof. Graham) of chemical affinity? If so, are there only two poles, a chlorous and a zincous, to each molecule—or, are there as many poles or combining surfaces as are indicated by the number of bright bands of its refracted light? And (if the undulatory theory of light may be depended on) would not these bands give an indication of the size of those surfaces or poles?

On Daguerreotyping the dark lines in the Solar Spectrum.—Being desirous to know whether corresponding lines exist in the actinic rays, I adopted the following method. The sun's rays were admitted into a dark chamber, between the edges of two pieces of sheet brass about eight inches in length and separated about the thirtieth of an inch, at one end, but in contact at the other.

Near the outside of the aperture thus formed, was placed a large lens, five feet in focus. Near the focus of the lens in the chamber, the rays pass through a prism and through a second lens of about 20 inch focus, which shows the dark lines very distinctly on white paper, at its focus, for rays coming from the slit. The prepared Daguerreotype plate, placed in the focus and exposed for one or two seconds, produces the effect.

In the Daguerreotype, which I send you there are two spectra caused by filing the brass slips so as to cause an aperture on side of the point of contact. I have placed the letters on the lines as given in Brewster's Optics, 1837, page 79. They would correspond with Prof. Draper's (see this Journal, March, 1848) if the H occupied the place of I.

I could not see the spectrum farther than the breadth of the second broad line at I in the direction beyond that line, when looking through the prism and slit at the sun. But by receiving the spectrum on paper stained with alcoholic tincture of turmeric, several dark lines can be seen beyond these and the blue appears to be changed to violet down to the line F.

ART. XXII.—*Synopsis of the Ichthyological Fauna of the Pacific slope of North America, chiefly from the collections made by the U. S. Expl. Exped. under the command of Capt. C. Wilkes, with recent Additions and Comparisons with Eastern types;* by L. AGASSIZ.

(Continued from p. 99)

EXOGLOSSUM, *Raf.*

THUS far a single species of this remarkable genus is known, which was first described by Lesueur, under the name of *Cyprinus maxillingua* in the first volume of the Journal of the Academy of Natural Science of Philadelphia, p. 185. Lesueur however already suspected that this species would constitute a separate genus, but until the discovery of another similar species he would content himself with referring it to the genus *Cyprinus*. His expectation of such a discovery has however not been realized, since the three species soon afterwards referred to this type by Rafinesque, who first introduced for it the name of Exoglossum, and those described at a later period by Kirtland and Valenciennes do not in reality belong to it. This is another among the many instances which show that the importance of generic peculiarities does not necessarily depend upon the number of species in which they occur. Rafinesque states that he had thought of calling this genus *Glossognathus*, but that this name appearing to him rather harsh, he has proposed that of *Exoglossum*, for the sake of euphony. Valenciennes remarks that he would have preferred that of Glossognathus, which he had himself introduced for this genus, before he read Rafinesque's paper. As matters now stand, we can have no choice, the name of Exoglossum standing by the right of priority and general acceptance.* DeKay is certainly wrong in referring this fish to the genus Catostomus with which it has no generic affinity, as I have already shown. In calling the typical species *Exoglossum Lesueurianum*, Rafinesque has paid a deserved tribute to the able French naturalist who discovered this fish; but in so doing, he has acted contrary to the universally acknowledged law of priority, which requires that specific names once established, should never be changed, unless they are absolutely objectionable, which is by no means the case in this instance. I do therefore not hesitate in restoring the specific name of *maxillingua*, first given to this fish by Lesueur, who discovered it in Pipe Creek, Maryland.

Valenciennes describes specimens from Pennsylvania. I have myself obtained numerous specimens from different localities;

* I have introduced this and similar other remarks in my paper, not merely with reference to the subjects under consideration, but chiefly as hints to American Zoologists, who in their writings seem not always to take sufficiently into consideration the traditional rules which have guided Naturalists since the days of Linnæus, in matters of nomenclature.

through the kindness of Professor S. S. Haldeman from the Susquehannah River; from Carlisle, Pennsylvania, through Prof. Baird; from Hollidaysburg, Pennsylvania, where it is called Cuttlips, or Niggerfish, through J. R. Lowrie, Esq.; from the Juniata River, where it is called Daychub and Niggerchub, through Prof. Th. C. Porter, and from Nichols, Tioga County, New York, where it is called Mullet, through R. Howell, Esq., so that its geographical range appears much wider than was known before.

As to the other species referred by Rafinesque to the genus Exoglossum, it may easily be ascertained on comparing his figures and descriptions, that neither of them belong to this tribe and one not even to this family. His *Exoglossum macropterum*, for which he himself afterwards proposed the generic name of *Hypentelium* is only a young Catostomus nigricans; his *Exoglossum annulatum* belongs to my genus *Melanura* of the family of Erythroids or Characini; and his *Exoglossum nigrescens* is only a synonym of his own Exoglossum annulatum with a less marked caudal spot. These nominal species have nevertheless been introduced by Valenciennes into his Histoire Naturelle des Poissons, upon the authority of Rafinesque, and hence reproduced by Dr. Storer in his Synopsis of the Fishes of North America. The Exoglossum dubium of Dr. Kirtland and Valenciennes, Exoglossum spinicephalum truly belong to the tribe of Chondrostoma, but as we shall see below they constitute a distinct genus, differing in some marked structural peculiarities from Exoglossum proper, as well as from the European genera of that tribe.

Thus restricted to its proper limits the genus *Exoglossum* is characterised by the following peculiarities: Body elongated, cylindrical, slightly compressed, covered with medium sized scales. Head flattened above; sides of head vertical; mouth terminal, and yet opening downwards owing to the shortness of the lower jaw, which fits within the upper and is entirely concealed from above by the broad upper lip, when the mouth is closed. The lower jaw has three distinct lobes, the middle one of which is larger, simulating a tongue, owing to the projection of a symphysis of its two branches between the lateral lobes of the lower lip. In fact the lip is wanting in the middle of the lower jaw, or reduced to a thin somewhat cartilaginous covering on the anterior portion of the jaw, whilst on the sides towards the angles of the mouth it remains large and fleshy, producing the appearance of a three-lobed lower jaw. The ventrals are further backwards than in most Cyprinoids, their insertion being nearer that of the anal than that of the pectorals, and their tip when bent back reaching the anal. The scales are almost quadrilateral, with rounded angles and a somewhat projecting posterior margin. Their vertical diameter is scarcely greater than the longitudinal. The centre of radiation is in advance of the centre of outline. The radiating furrows do not converge regularly

towards the centre, but occupy near it a broader field than usually and diverge towards the posterior margin in such a manner that the concentric ornamental ridges of the lateral fields and of the anterior field are not intersected by them.

The pharyngeal teeth are arranged in two rows, the outer one with four somewhat compressed teeth, curved inwards, terminating with a small hook and provided with a small grinding surface upon the inner margin. The inner row has only a single tooth, more conical than the outer ones and much smaller. The insertion of these teeth lower upon the branch of the symphysis than usually is also quite characteristic.

10.

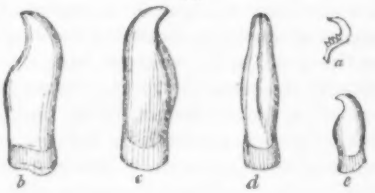


Fig. 10, *a*, represents the right pharyngeal of Exoglossum maxillingua, *b*, *c* and *d*, the longest tooth of the outer row from three sides and *e*, the smallest in profile.

[Note on *Melanura*, Agass.—Few fishes have been referred to so many different groups with which they have no affinity as the type of the genus I have called *Melanura*. First described by Rafinesque in 1820, in the first volume of the Journal of the Academy of Natural Sciences of Philadelphia, under two different names, as *Exoglossum annulatum* and *nigrescens*, it reappears in 1842 as a new species in DeKay's Report, without any reference to Rafinesque, under the name of *Leuciscus pygmæus*.* It is introduced a second time in the same work under the name of *Hydrargyra atricauda*, though Rev. Z. Thompson had already described it anew shortly before the publication of that work, under the name of *Hydrargyra fusca* in his History of Vermont. In 1843, Dr. W. O. Ayres described it for the sixth time as a new species under the name of *Fundulus fuscus* in the 6th volume of the Boston Natural History Journal, p. 296. He however added to our knowledge of its structure by describing correctly the jaws. In 1846 Dr. Storer trusting implicitly to his predecessors, mentions it still under the head of three different genera in his Synopsis of the Fishes of North America, as Leuciscus pygmæus, Fundulus fuscus and Hydrargyra fusca.

All these descriptions relate only to two species of one and the same genus, which however belongs neither to the family of Cyprinoids, nor to that of Cyprinodonts in which the intermaxillaries form the whole margin of the upper jaw, but con-

* I am indebted to Professor Baird for specimens of the Leuciscus pygmæus of DeKay from the same locality as those described in the Natural History of New York, without which I would hardly have suspected even the generic identity of that fish with DeKay's own Hydrargyra atricauda.

stitutes a North American representative of that curious type first described by Gronovius, under the name of Erythrinus, from the Brazils. The genus Erythrinus, divided by J. Muller into two genera: Erythrinus proper and Macrodon, was referred by him to his family of Characini and afterwards raised by Valenciennes to the rank of a distinct family under the name of Erythroids, to which he has added the genera Lebiasina *Val.*, from Lima, Pyrrhulina *Val.*, from Surinam, and Umbra *Kram*, from Hungary. My genus Melanura is the North American representative of the European Umbra. It may be characterized as follows: Body elongated, compressed; dorsal far behind, extending over the space between the ventrals and the anal, as far back as the anal itself; ventrals when bent back reaching the anal. Mouth opening forwards; lower jaw longer than the upper, armed as the intermaxillaries and palatines with small recurved velvet teeth; no teeth in the upper maxillaries *which form the sides of the upper jaw;* pharyngeal teeth like those of the jaws, but smaller. Cheeks, opercle and top of the head covered with scales. A few large pores along the preopercle, the mastoids and on the top of the head. Gill openings very large; membrane connecting the four branchiostegal rays overlapping one another below. No Pseudobranchiæ. Caudal fin rounded. Hydrargyra limi, *Kirt.*, is another species of this genus, and Professor Baird has discovered others in our western waters, which he has forwarded to me for comparison and description.* The first species mentioned above, must retain the specific name given to it by Rafinesque. I shall therefore call it *Melanura annulata.* The little figure given of this species by Mr. Thompson, in his History of Vermont, p. 137, is very characteristic.]

Campostoma, *Agass.*

As stated above, the Exoglossum dubium of Dr. Kirtland, though closely allied to the typical species first described by Lesueur is not generically identical with it.

It is true, its pharyngeal teeth have the same general arrangement, there being an outer row of four teeth on each side, and an additional small tooth within that row; but the teeth themselves inserted in a cluster abreast of the rather spur-like lateral dilatation of the pharyngeal, are more elongated, hardly hooked at all, and their inner margin presents a long narrow grinding surface, very similar to that of the genus Chondrostoma proper.

The American fish differs however, in having two rows of teeth, while Chondrostoma has six teeth in a single row. Besides, the form of the mouth is very different in the two, being square in Chondrostoma and arched in Exoglossum dubium.

* I have received another from Davenport, Iowa, through the kindness of Professor Sheldon. I shall describe all these fishes comparatively, on another occasion, and then discuss their synonymy more fully.

This shows plainly that however closely allied, they are types of different genera, and I shall introduce the name of Campostoma for the American form. The scales bear a close resemblance to those of Exoglossum; their longitudinal diameter however prevails over the vertical and the radiating furrows diverge more towards the posterior margin. The body is fusiform, rather stout, somewhat compressed; the peduncle of the tail long and powerful. Fins of medium size and rounded. Head broad, compressed; its sides vertical; eyes high upon the sides of the head, reaching its upper outline. The species I have mentioned in my notice of the fishes of the Tennessee River, under the names of *Chondrostoma prolixum* and *pullum** belong to this new genus, as also *Exoglossum spinicephalum* of Valenciennes. Since it is not my object to describe here the species of North American Cyprinidæ, upon which Professor Baird is preparing a monograph, I shall not enter into further particulars respecting this genus, remarking only that the species of Campostoma assume a very different appearance in different periods of the year, according to their sexes; Exoglossum spinicephalum of Valenciennes, for instance, being the male in its breeding dress of the same species Dr. Kirtland has described under the name of Exoglossum dubium. Leuciscus prolixus *Storer* again, is synonymous with *Ex. dubium* Kirtland. The young differ also greatly from the adults, and I have satisfied myself from a large collection of specimens of different ages and sizes sent me by Dr. I. H. Rauch, of Burlington, Iowa, that the fish I have described as Chondr. pullum, in a note to my notice on the fishes of the Tennessee River, is a very young specimen of the same species. It is but recently I have been able to identify this fish with one of Rafinesque's species. Knowing how common it is in our western waters, I could hardly believe he should have overlooked it, and yet it was not until I had made out most of his species I perceived that among the few remaining ones his Rutilus anomalus agrees in every respect with it. This name *anomalus* being by many years the oldest, must supercede all others, and the species shall henceforth bear the name of *Campostoma anomalum*. I would also consider Rutilus melanurus *Raf.*, as another synonym of this species, were the dorsal not described as having 15 rays. Some of the species described lately as Chondrostoma from the Old World may belong to this genus.

11.

Fig. 11, *a*, represents the right pharyngeal of *Campostoma anomalum*, *b* and *c*, one tooth of the outer row from two sides, and *e*, the same from the inner side to show the grinding surface.

* See this Journal, vol. xvii, p. 357.

Pimephales, Raf.

This genus was established by Rafinesque for the reception of a small species little known then as now to anglers. The single specimen from which he drew the generic as well as specific characters of this fish was taken at Lexington, Ky., with a small hook. The peculiar features of the fish mentioned by Rafinesque in his description, leave no doubt respecting its identity. The large irregular black spots of the anterior base of the dorsal, its first, simple, shorter, obtuse, hard ray, together with the blackish head and blunt snout, readily distinguish it from any other fish of the same family in the vicinity from which it is described. The generic characters as given by this naturalist, are: Body oblong, thick, and scaly, vent posterior, nearer to the tail, head scaleless, fleshy all over, even over the gill covers, rounded, convex above and short. Mouth terminal, small, toothless, with hard, cartilaginous lips. Opercle double, three branchial rays. Nostrils simple, dorsal fin opposite the abdominals, with the first ray simple and cartilaginous. Abdominal fins with eight rays. This generic diagnosis exhibits most of the defects of the greater number of such descriptions. To mention that the body is *scaly*, the *head scaleless*, the *mouth toothless*, the branchiostegal rays *three in number* is only to repeat as characters of one what in reality belong to all the genera of the family. I am sorry to add that this practice of referring at random to families, genera or species the characters observed, is continued to this day by the majority of our Naturalists. Most of their generic descriptions are only vague specific descriptions, and their specific descriptions refer chiefly to individual peculiarities of the specimens before them. They are at best a kind of portrait of particular individuals without much likeness.

What Rafinesque says of the nostrils being simple is absolutely false, as in all Cyprinoids there are two openings of the nostrils on each side of the head; the upper one is crescent-shaped, the lower or anterior one oval; both close together.

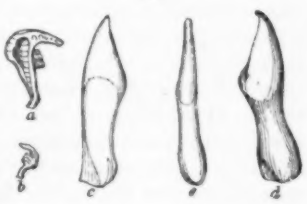
The name proposed by Rafinesque is abbreviated from Pimelekephale, which means *fat-head*, an allusion to the round fat head. In the Ichthyologia Ohiensis, Rafinesque gives Flat-Head as the meaning of the name he proposes for the genus: but this is evidently a misprint for fat-head.

This genus is very closely related to Campostoma, in which however the scales on the back in front of the dorsal are as large and as well arranged as those behing this fin, while in Pimepheles they are very much reduced in size, crowded and irregular in form and arrangement in front of the dorsal. The spine in the dorsal, as well as the rounded form of all the fins are also characters which distinguish this genus from Campostoma. But what

particularly characterizes this genus externally is the short, conical head, the height and length of which are nearly equal. The snout is broadly rounded both vertically and laterally. The mouth, which is terminal and not beneath the snout, opens slightly upwards. The lower jaw is short, arched in front and bent upwards, giving it a somewhat spoon-shaped form. At present, we know of only one species belonging to this genus, which Rafinesque described under the name of Pimephales promelas. He never saw more than one single specimen of this remarkable fish, which he obtained from Mr. W. M. Clifford, of Lexington, Kentucky, in 1820. It is not mentioned in the great Histoire Naturelle des Poissons, by Cuvier and Valenciennes. Dr. Kirtland, to whose indefatigable ardor we are indebted for so much valuable information upon the fishes of the Ohio, seems to be the only Ichthyologist who has noticed this fish from personal observation, since it was first described by Rafinesque. Dr. Kirtland describes it from three specimens caught in Trumbull County, Ohio. I have myself had the good fortune to obtain a large number of specimens in the smaller brooks west of St. Louis in Missouri. The species fully deserves the specific name given to it by Rafinesque on account of the contrast between the almost black color of the head and the light tint of the body. The largest specimens I have seen did not exceed three inches and a half in length.

Heckel, who has devoted more attention to the study of the pharyngeal teeth than any other Ichthyologist has gone so far as to consider their number of generic importance. To some extent this is true ; for I find that in some types of this family there is a remarkable constancy in that respect, though in others slight variations are observed. In the tribe of Chondrostoma for instance, the genera after being characterized by other structural peculiarities, present further differences in the form and number of their pharyngeal teeth, and even in the form of the pharyngeal bones. In Pimephales there are constantly four compressed teeth on each side, the inner edge of which presents a flat, narrow, grinding surface, while the outer edge is arched and terminates either abruptly or as a small hook curving over the side of the grinding surface. The spoon-shaped lateral dilatation of the pharyngeals is particularly prominent in this genus. Fig. 12, *a*, represents the right pharyngeal of *Pimephales promelas* enlarged from the outer surface to show this projection, *b* represents the same bone from the dental side, in natural size: *c* and *e*, are profile and side views of one of the teeth without hook,

12.



and *e*, one hooked tooth in profile. The scales of this genus are also very peculiar; their longitudinal diameter is much shorter than the vertical, as in *Plargyrus*, and the centre of radiation is much nearer to the anterior, than to the posterior margin; the concentric ridges of the ornamental layer of the outer surface are close together, and only interrupted by radiating furrows upon the posterior and lateral fields of the scales. The tubes of the lateral line short, broad and curved downwards upon the middle of the posterior fields of those scales.

Hyborhynchus, Agass.

In respect to the arrangement of the scales, and the structure, position and form of the fins, this genus does not differ from Pimephales; it is chiefly distinguished by characters of the head and the pharyngeals. The head is long and flattened above; the profile descends suddenly on reaching the nostrils, forming a very blunt, gibbous snout, (whence the generic name Hyborhynchus). The mouth is small, beneath the snout, and cut horizontally. The lower jaw is flat, broadly rounded in front and shorter than the upper jaw. The sides of the head are vertical and form with its upper surface an angle or ridge behind the eyes. The upper border of the eye reaches the top of the head. The pharyngeals have about the same form as in Pimephales, the symphysal process being only more straight, with a deeply emarginate side; the teeth cut vertically and not obliquely as in Pimephales, with a narrow, flat grinding surface and a slightly arched tip. Fig. 13, *a*, represents the right pharyngeal of *Hyborhynchus notatus* in natural size, *b*, slightly magnified, *c* and *d*, two teeth more highly magnified, seen in profile, and *e*, one seen from the grinding surface. The scales are higher than long, and the centre of radiation very forwards as in Pimephales; but the radiating furrows are not so numerous, and the tubes of the lateral line are narrow and straight.

13.

For the possibility of identifying one more of Rafinesque's species, I am indebted to the Rev. T. S. Fall, of Frankfort, Kentucky, who sent me specimens from the very locality where Rafinesque used to collect, among which I have recognised without difficulty his Minnilus notatus, *Raf.*, the type of my new genus Hyborhynchus. I had already received specimens of this fish before, through the kindness of Prof. Baird, from various localities in Pennsylvania and Ohio, under the name of Pimephales elongatus, which very correctly expresses the general affinities of this fish. I am indebted to J. Sullivant, Esq., of Columbus, for specimens from the Scioto River, to Dr. Watson for others from

Quincy, Illinois, to Dr. I. H. Rauch, for others from Burlington, Iowa, to Prof. J. M. Safford, for specimens from Lebanon, Tennessee, to Col. B. L. C. Wailes for others from Natchez, Mississippi; I have myself caught specimens at Beardstown and Lasalle, Illinois. I received from an unknown contributor, with many other species, one specimen from Rome, New York. I find it also among Professor Baird's specimens from Westport (Lake Champlain) and among mine from Lake Huron. This most extraordinary range is hardly covered by a single species, and yet I can find no specific differences between the specimens even from the most remote localities. I must remark however, that from some I have only a few rather indifferently preserved specimens.

Hybognathus, Agass.

In this genus the body is more of a fusiform shape than in Pimephales; the head is triangular or wedge-shaped, and the snout hardly blunt; the profile not descending suddenly on reaching the nostrils. The top of the head is convex and rounded at the sides instead of forming a prominent ridge. The mouth is small and terminal; the lower jaw is quite thin and flat; its symphysis is angular and prominent, being surmounted by a slight tubercle, in allusion to which I have called the genus Hybognathus.

The upper jaw partakes in a less degree of the angular outline of the lower jaw, which is shorter than the upper, and fits within it. The dorsal and anal fins, though similar in form, yet differ from those of Pimephales, in having the longest simple ray the longest ray of the fin, making the anterior and outer angle pointed. The pectorals and ventrals are slender and pointed; the caudal is deeply forked. The scales are as large on the back and anterior portions of the body as behind the dorsal and ventral fins. Scales subtriangular, owing to the greater vertical diameter, the prominent posterior margin and the very forward position of the centre of radiation.

Ornamental concentric ridges closer together upon the very narrow anterior field. No radiating furrows upon this, and the lateral fields, but only upon the posterior field; this however, being by far the greatest, the furrows appear rather numerous. Tube of the lateral line beginning forwards in the centre of radiation, but extending only to the middle of the posterior field. The pharyngeals have their lateral dilatation almost square, with an acute angle from the most projecting point; their upper end is club-shaped. Teeth, four in one row, of the same form as those of Campostoma.

14.

Fig. 14, *a*, represents the right pharyngeal of Hybognathus in natural size, *b*, enlarged, and *c* and *d*, one tooth in profile and from the side, still more magnified.

Hybognathus nuchalis, Agass.

For specimens of the species which constitute the type of this genus, I am indebted to Dr. Watson of Quincy, Illinois. I have also received some from Dr. Rauch of Burlington, Iowa, and others from Dr. Engelman of St. Louis, Missouri. The largest specimens are nearly four inches long. The dorsal and ventral outlines are arched equally. The length of the head is one-fifth of the entire length or a little less than the greatest height of the body. The eye is of moderate size, and slightly elliptical in form, its hinder margin is nearer the posterior angle of the opercle than the end of the snout. The opercle is higher than long, its lower border is convex, the posterior emarginate. The upper maxillary does not reach the vertical line of the anterior border of the eye. The dorsal begins at the highest part of the back slightly in advance of the ventrals; its height is greater than its length, and is not emarginated behind; its last ray as to length, is to the longest ray of the fin as 1 to 2. The anal fin is one-third smaller than the dorsal. The lateral line is straight, except over the pectorals, where it bends upwards, and ends above the opercle. There are four rows of scales between this line and the ventrals, and five above it.

Back, dark olive color, with a darker stripe from the neck to the base of the dorsal, extending also along the back, between the dorsal and the caudal. A greyish, diffuse, longitudinal band above the lateral line; sides silvery.

P. 1, 14; D. 2, I, $6\frac{2}{1}$; V. 1, 7; A. 2, I, $6\frac{2}{1}$; C. 4, I. 9, 8, I, 5.

In the method adopted by Valenciennes, all the fishes of the family of Cyprinoids described above from the North American continent, would be referred to his genus Sclerognathus, to Catostomus proper, to Exoglossum and to Chondrostoma. His *Sclerognathus* would include Rafinesque's genera Carpiodes and Ichthyobus, and my Bubalichthys; *Catostomus*, as he limits the genus, would cover Cycleptus, Moxostoma, Ptychostomus, Hylomyzon and Catostomus proper. Whether Exoglossum would be made to include my genera Hyborhynchus and Hybognathus, or whether these would be referred by him to my genus Chondrostoma, I do not know; Campostoma, which is much nearer to Chondrostoma, being already referred to Exoglossum would probably carry with it Hyborhynchus and Hybognathus, and yet these types are much more closely related to Chondrostoma than to Exoglossum; but such inconsistencies are everywhere the unfortunate results of a loose identification of genera. I have no doubt however, that my genus Acrocheilus would be considered by every Ichthyologist as nearest akin to Chondrostoma. All the genera of North American Cyprinidæ not yet enumerated above have been referred by Valenciennes to his genus *Leuciscus*, which in my estimation is a mix-

ture of heterogeneous types, and must be subdivided not only into genera, but even into tribes. But before expressing any opinion upon the closer affinities of these more restricted genera it is advisable to illustrate successively their structural characters and to compare them with one another. I begin with

Chrosomus, Raf.

The genus Luxilus of Rafinesque embraces two different types, which he has himself separated as subgenera under the names of *Chrosomus* and *Luxilus* proper. These two types differ in so many structural peculiarities that I do not hesitate to consider them as different genera. These differences are indeed so obvious, that DeKay, though he does not refer to Rafinesque's groups, has elevated to the rank of a distinct genus which he calls *Stilbe*, the type which Rafinesque calls *Luxilus* proper, whilst Heckel has given it a third generic name, calling it *Leucosomus*.*

Kirtland is the only American Ichthyologist who has paid due regard to the work of Rafinesque upon our western fishes, and we find in consequence the species now under consideration described by him as *Luxilus erythrogaster*, he not having deemed it necessary to enquire into the merits of the subgenera Chrosomus and Luxilus proper. Kirtland however erroneously introduces a genuine *Alburnus* into the genus Luxilus.

Storer refers *Luxilus* erythrogaster to the genus *Leuciscus*, without giving his reasons for the change.

I shall of course, retain Rafinesque's name *Chrosomus*, for the type of Luxilus erythrogaster and that of *Luxilus* for the other type, which embraces at the same time the genus *Stilbe* of DeKay and the genus *Leucosomus* of Heckel. It is more difficult to trace the generic differences distinguishing *Chrosomus* and *Phoxinus* as they are very similar in external appearance; yet upon careful comparison such differences are observed between them, that no doubt can remain respecting the propriety of considering them as distinct genera, if structural peculiarities are at all indicative of generic differences. In the first place Phoxinus has two rows of pharyngeal teeth, the outer, numbering four or five teeth, the inner, one or two, whilst Chrosomus has only one row of five teeth. Moreover, in Phoxinus the point of the teeth is strongly hooked, and their inner margin entire, while in Chrosomus that margin is flattened into a grinding surface, the teeth terminating however with a small hook.

* It may not be out of place to remark here that *Cyprinus Smithii* of Dr. now Sir John Richardson, upon which Heckel has founded his genus *Glossodon* is nothing else but our common *Hyodon*.

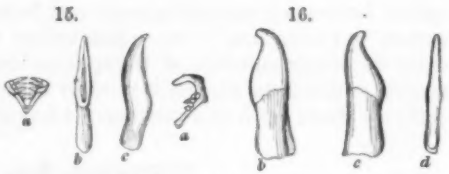


Fig. 15 and 16 represent the pharyngeals and teeth of these two genera side by side: 15, *a*, the right pharyngeal of Chrosomus erythrogaster, *b* and *c*, one tooth in profile and from the grinding surface. Fig. 16, *a*, the right pharyngeals of Phoxinus varius of Europe, *b*, *c*, *d*, a tooth of the outer row from three sides.

In my paper upon some new species of Cyprinoids from the Lake of Neuchatel, printed in 1835 in the Transactions of the Natural Historical Society of that city, I characterised the genus Phoxinus as follows: "Body cylindrical, stout, covered with very small scales. Pharyngeal teeth pointed. Caudal furcate." Heckel in his Ichthyology of the Travels of Russegger, has added the following particulars: Dentes raptatorii 2–5; 5–2. Os anticum; labia teretia; cirri nulli. Pinna dorsalis et analis brevior, illa pone pinnas ventrales incipiens. Squamæ minimæ membranaceæ, adherentes, vix se invicem tegentes.

The facilities I have had for comparing Phoxinus and Chrosomus, which are representative genera, respectively limited to the Old and New World, enable me to furnish further information upon their peculiarities, which is the more needed as the description of Rafinesque is very brief and incomplete.

The bluntness of the head and the shortness of the cylindrical body of Phoxinus is very characteristic and contrasts in a striking manner with the more pointed head and fusiform body of Chrosomus. In both these genera the scales are very small, thin, membranaceous and hardly appressed to the body, which circumstance has misled Heckel into the statement that the scales hardly cover one another; yet they are imbricated in the usual manner; but they are not arranged in quite so regular rows as in most other genera. Phoxinus and Chrosomus are in fact with Moxostoma the only groups I know in the family of Cyprinoids in which the lateral line is not regularly continuous from the upper angle of the opercle to the base of the caudal. In Phoxinus it breaks up for the most part, not far behind the tip of the pectorals, but reappears generally above the ventrals for some short space, and here and there single perforated scales may be traced to the end of the tail; in Chrosomus it is more continuous, extending usually without interruption as far back as the space between the ventrals and the anal, and then more interruptedly backwards. The scales themselves differ so far that they may be recognized, even when isolated; in Chrosomus the concentric ridges upon the surface of the ornamented layer of the scale are closer together and interrupted at regular intervals in every direction from

the centre, in such a manner as to give rise to radiating furrows diverging on all sides In Phoxinus the ridges are fewer, and they are only distinctly interrupted upon the posterior and lateral fields of the scale, and scarcely at all upon the anterior segment, so that the anterior margin exhibits few furrows, if any. The tubes of the scales in the lateral line are also different. In Chrosomus they are narrower, more tubular and closed, and not extending far beyond the centre of growth of the scales; in Phoxinus they have the appearance of broad channels occupying almost the entire field of the scale from margin to margin. The number of teeth assigned to Phoxinus by Heckel is not quite so constant as he seems to believe; I find occasionally only four teeth in the outer row instead of five, and only one in the inner row instead of two; but I have never seen two rows in Chrosomus. The form and comparative size of the fins are about the same in the two genera; they differ only in relative position, the dorsal being placed farther back in Phoxinus than in Chrosomus. The mouth is terminal and yet when it is closed, the snout projects slightly beyond its crescent shaped outline; this feature is particularly marked in Chrosomus. However, when the mouth is opened the lower jaw of Chrosomus projects more than that of Phoxinus. Neither of these fishes have barbels. In Chrosomus as well as in Phoxinus, the males differ from the females in having brighter colors, especially in the spawning season.

The *Rutilus? ruber* of Rafinesque, which he has himself never seen, and of which he says that it may belong to his genus Rutilus, *or to any of this tribe*, a slender fish, only two inches long, compressed and of a *fine purple red*, can be nothing but Chrosomus erythrogaster. There is no other fish in the Ohio basin answering to this description.

Ptychocheilus, Agass.

There are few Cyprinidæ in which the mouth is widely cleft; few which have a slender appearance and whose form indicates swift motion. Among the best known of that character I may mention Aspius rapax from the Danube. The new genus which I am about to describe, has however, this appearance in a very eminent degree; and, though it would not appear safe to establish a new genus among Cyprinidæ from a single specimen deprived of its intestines and of its pharyngeal teeth, and which, in such a state, affords very imperfect means of comparison, I have however, not the slightest doubt that the fish before me cannot be referred to any of the many genera which have been established among Cyprinidæ. Its mouth is far more widely open than that of any Cyprinoid known to me, and its lips are very fleshy, especially the upper lip, the inner surface of which is deeply folded so as to present radiating folds all round its edge

when the mouth is open. The lower lip is also very fleshy around the symphysis of the two branches of the lower jaw, and presents the same folds; but, upon the sides it tapers into a thin membranous fold deeply separated, by a furrow, from the skin covering the lateral branches of the lower jaw. This fold unites at the lower extremity of the intermaxillary bone, and presents in many respects a remarkable resemblance to the folds of the membrane of the lower jaw in Muræniдæ. The skin covering the tongue and extending between the inner sides of the two branches of the lower jaw, is also remarkably folded. As such characters occur in no other genus, I am well justified in considering this as a peculiar type of the family. There is not the slightest indication of a tentacle at the angle of the mouth between the intermaxillary and upper maxillary bones.

The branchiostegal rays, three in number as usual, seem at first rather short, and broad, but, upon close examination it is found that behind and above the part of these bones which is seen externally, there is a long prolongation arising behind the suboperculum, thus giving additional strength to the gill covers. The branchiostegal membrane unites with the chin in advance of the humerus, so that the branchial fissure does not extend to the side of the hyoid bone.

One of the most striking features of the fish is the great elongation of the head, which, in outline, truly resembles that of Lucioperca. The body is cylindrical and slender, tapering slightly toward the caudal, so that the tail is very strong and powerful, affording another evidence of the energetic movements this fish can perform. The dorsal and the ventrals are rather backwards; the ventrals much nearer to the anal than to the pectorals. The pectorals are rather large and elongated, and by no means so broad proportionally as the ventrals. They consist of one hard ray, and sixteen articulate rays, the two lowest of which are simple. In the ventrals there is in advance one simple ray, followed by eight branching rays. In the dorsal, which has the same form as the anal, there are two small rays in advance of the large simple one followed by eight branching rays, the last of which is a double ray. The anal has the same structure, but there is one ray less. In these two fins, when shut, the rays overlap each other. This is also the case with the central rays of the caudal, in which there are nine branching rays in the upper lobe, and eight in the lower. A large simple ray on each margin and seven or eight small rays near the base. The lateral line considerably curved behind the operculum, follows at first the middle line of the body, but is nearer the abdomen than the back, upon the sides of the abdomen, and resumes its medial position upon the tail. The scales have the ordinary appearance of Leuciscus scales, but are rather smaller than in the common Leucisci. It is a great

pity that neither pharyngeal bone nor intestines have been preserved so that the relation of this fish to the ordinary Leucisci cannot be well ascertained.

I have preserved the characteristic of this genus as I had written it four years ago when I had only the specimens of the Exploring Expedition before me, without any trace of pharyngeals or intestines, that I may be able better to show how correctly we may judge of certain structural peculiarities not within our reach from other facts we may have observed. The predatory habits of the type of this genus were inferred from the form of its body and from the shape of its mouth. Now we know also the teeth from another species sent me from San Francisco by my friend T. G. Cary, Jr., Esq., the case is perfectly plain and I am confident in asserting that the species of Ptychocheilus are among the most voracious of the whole family of Cyprinoids, exceeding probably all others in their rapacious dispositions.

17.

Fig. 17, *a*, represents the right pharyngeal of Ptychocheilus major, from behind; *b*, one of the teeth of the outer row magnified twice.

Ptychocheilus gracilis, Agass. & Pick.

The back bluish grey. Silvery upon the sides. Head and cheeks golden color. Fins yellowish orange. The middle of the caudal grey.

From Willamet Falls, Oregon.

Ptychocheilus major, Agass.

I am unable to indicate the colors of this species, but it is easily distinguished from the preceding by its larger scales.

From San Francisco, California.

Mylocheilus, Agass.

It seems to be a characteristic feature of the Cyprinidæ of the Columbia River, to have their mouth clothed with a hard grinding sheath similar to the horny covering of the Turtles. We have seen the Acrocheilus provided with a flat horny chevron upon its lower jaw, and a similar but narrower sheath upon the inner margin of the upper lip. In the genus Mylocheilus the mouth has a different shape. At first sight it does not differ at all from that of the common Leucisci, or rather from the type which represents the European Leucisci on the shores of North America, and of which Dr. Storer's Leuciscus pulchellus is this type, which differs from the European Leuciscus in having a small tentacle, like the European Gudgeon upon the angle of the upper jaw be-

tween the extremity of the intermaxillary and upper maxillary bones. In addition to this peculiarity which our Mylocheilus has in common with the Eastern American Leucisci, our fish has a horny sheath surrounding both the upper and lower jaw, so that we are led to consider it without hesitation as a new generic type, peculiar, as far as we know at present, to the Northwestern coast of America. A close examination of the pharyngeal system of teeth fully sustains the impression, first received from the examination of the jaws, that Mylocheilus constitutes a distinct genus in the family of Cyprinidæ; for its teeth differ entirely from those of the common Cyprinidæ known at the present day. Far from having the slightest resemblance to the teeth of either the European or East American Leucisci, its teeth resemble more those of the true Carp's in being large and rounded, while the Leucisci, which it most nearly resembles in external appearance, have their teeth conical, pointed and hooked at the tip. However, these teeth differ from those of the genus Cyprinus proper in having a flat rounded crown without sulci and gyri. These teeth are arranged in one main row of five, in which the anterior teeth are the largest, and the posterior are much smaller and somewhat compressed and hooked. One tooth is wanting in the left row, but its base of insertion shows that it has recently fallen off. In addition to those teeth, there is above on each side one small tooth similar in form to the common small tooth of Leucisci; underneath on each side, one or two immature teeth sticking in the gum. Were it not for the circumstance that the two arches of the pharyngeal bones are free and movable upon their symphysis, one might suppose this apparatus to have belonged to some Labroid Fish; so great is the resemblance of its rounded teeth to those of that family. The horny plate against which this apparatus moves upon the basilar bone is ovate, lanceolate. The arches of the gills are provided, on their inner margin with tufts of small teeth forming canals which alternate between the adjacent arches, the upper ones of the first arch only consist of strong hooks. The nostrils are large; the anterior, tubular; the posterior crescent-shaped.

Water-pores seem to be fewer than in Acrocheilus. I perceive only those larger ones which follow the shoulder bone, the mastoid, the preoperculum, the suborbital, and the lower jaw. The branchiostegal membrane unites in advance of the humeral bone, so that the branchial fissure does not extend to the side of the hyoid bone. The pectorals are large, and longer than the ventrals, the latter placed nearer to the anus than to the pectorals. The dorsal begins in advance of the ventrals which are opposite the middle of that fin. There is one strong simple ray, in the anterior margin of the pectorals, followed by seventeen branching and articulated rays, the last of which however are simple. The ventrals consist of one simple ray and eight branching ones.

When shut, the rays of these fins are brought close together, but do not overlap each other as is the case with the rays of the dorsal and anal and with the middle rays of the caudal. The dorsal has a narrow base, as has also the anal, both fins having the same structure, differing only in size. There are two small rays in advance of the long ray of the dorsal, followed by seven branching rays the last of which, however, is a double ray. The anal has precisely the same number of rays. The caudal is large, furcate, and has eight smaller rays along the upper and lower margin; then, on each side, a large simple ray. The upper and lower lobes are apparently equal; there is, however, one ray more in the upper lobe, that is to say, nine above and eight below. The inner ones overlap each other when the fin is shut. The scales are of medium size and have the common appearance of Leuciscus scales. The lateral line slightly bent downwards behind the operculum, follows about the middle of the side. The intestine has twice the length of the abdominal cavity, and is a simple tube tapering from the stomach backwards. The air bladder as usual, consists of two divisions with a tube opening into the pharynx. The humerus forms a widely rounded angle above the pectorals.

18.

Fig. 18, *a*, represents the right pharyngeal from behind, *b* from within so as to show the crown of the teeth from above, *c* represents the same in profile to show the insertion of the teeth; *d* and *d'*, represent the same tooth, the second above the symphysis, from two sides showing how much it is compressed; *e* is a side view of the outer or upper tooth of the main row.

Mylocheilus lateralis, Agass. & Pick.

Greenish blue above with a reddish line upon the sides. Upper fin greenish. The edge of the caudal reddish. Pectorals and ventrals orange. The horny plate of the mouth is of a brownish orange.

Caught in the Columbia River at Fort Vancouver in Oregon.

(*To be continued.*)

ART. XXIII.—*Discovery of a Coal Basin on the Western borders of the Lake of the Woods;* by HENRY R. SCHOOLCRAFT.

FACTS observed during the several expeditions to ascertain the sources of the Mississippi river in 1820, and in 1832, under the authority of the government, denote this stream to originate in the geological drift, or erratic block stratum, resting on silurian strata. This drift composes a wide crescent-shaped range of high lands, sweeping round from the Otter-tail lake to the sources of the St. Louis river of Lake Superior, which constitute the northern rim of the valley. It forms a well defined water-shed, which pours its drainage south into the Gulf of Mexico north into the great Lake Winnipek; and southeasterly into Lake Superior. The French denominate it *Hauteur des Terres.* From the principal lake, which occupies its summit, it has, since the era of the last expedition referred to, been called the Itascan summit or water-shed. Mr. Nicollet who ascended it, in 1836, found its extreme altitude to be 1680 feet above the Gulf of Mexico.

The surface consists of immense heaps and wave-like deposits of oceanic sand, and comminuted sandstones and schists, with boulders of both the sedimentary and igneous rocks. Although the silurian series are generally concealed by these deep and wide-spreading deposits of the drift era, yet, they appear in horizontal positions at the Naiwa rapids at the foot of the Itascan range; on the Metoswa rapids, below Queen Anne's Lake; and, very distinctly at the Pakagama Falls, at the foot of the great sphagnous plateau below the inlet of Leech Lake river.

The whole column of formations is manifestly supported by the igneous group of rocks, heavy boulders of which lie tumbled together in many of the sub-valleys, as if they could not have been transported far from their parent beds. Whether the silurian strata be, however, imposed directly on the igneous, or exist in juxtaposition with them, is not certain. This only can be stated, in regard to the general arrangement, that in descending the channel of the Mississippi from Itasca Lake, the sandstones, grits, and quartzite are encountered at the localities mentioned. At a point, where the river has worn its channel 550 feet into the geological formations, (Dis. Sources Miss., p. 582,) the pyrogenous rocks are found in place, in its bed and on its banks. Such are the appearances near the influx of the river De Corbeau, in latitude 46°, and below that point. Rocks of igneous character have crossed the track of the Mississippi below this point—covering a belt of about one degree of latitude in width—that is to say, from the small river Nokasippi, near the Crow Wing branch, to the influx of the Sac or Osakis. Mr. Norwood, in his geological visit in 1848, did not find rocks in place above the De Corbeau, and did not

ascend the river above Sandy Lake inlet. (Owen's Geol. Rep. of 1852, p. 293.)

These preliminaries will enable the reader, better to comprehend the following remarks. In mere point of altitude, the Itasca summit is not above the coal measures on the Alleghanies, which, by the best atlases, do not exceed sixteen hundred feet. (Black's Atlas, Edin.) The basin of the Lake of the Woods, is, however, at a lower point, occupying one of the northern plataux of this continental water-shed. Reports of the existence of coal in this remote basin, while I resided in the West,—taken in connection with the specimens of its mineralogy, brought to me from time to time, by the aborigines, did not sustain the conclusion. Nothing of the kind had been observed by the Commissioners and Surveyors, acting under the treaty of Ghent, who visited the lake to establish the national boundary, in 1823. Among these officials, were Maj. Joseph Delafield of New York, and Dr. John Bigsby of Nottingham, England—both zealous students of natural history. The only rock-specimen brought to me by the aborigines, proved to be a species of black steatite, a material which is much valued, by them, in their pipe sculpture and this afforded no evidence of the propinquity of coal-bearing strata. Neither were such strata observed by the late Mr. Keating, who accompanied Maj. Long in his expedition through the lake in 1823.

The first evidence of the silurian rocks in that quater, comes from Dr. Richardson, who passed through that lake in 1848, in the search after Sir John Franklin. He observes that in crossing the pyrogenous summit* between Lake Superior and Lake Winnipek, in the direction of the Rainy Lakes, silurian strata occur on both flanks of it. He further observes, that Dr. John Bigsby presented a species of Pentamerus to the British Museum, which he had procured at the Lake of the Woods. He informs us that the eastern margin and island of that lake, are granitic, and hence infers, with good judgment, that Dr. Bigsby's fossil was probably found on an arm of its western coasts. (Arctic Searching Exp., p. 47)

It is on the western coast of this lake, that recent information of a reliable character assures me, that large deposits of coal exist. The formation lies south of the national boundary line of 49° which crosses the Portage du Rât.

It is not the result of experience, to pronounce a country absolutely barren of resources, which has an uninviting aspect, but which is at the same time, unexplored, or imperfectly explored. The importance of coal in that quarter of the continent can hardly be over estimated. Immense tracts of fertile plains, without forest or fuel, exist along the valley of Red River, at Pembina, and

* He infers the summit to be a development of the beds of granite of the Thousand Islands, at the head of the St. Lawrence.

at points north of it, to which such a discovery must be of inestimable value. These extend south, quite to the St. Peters, or Minnesota, up to which, the transportation would be wholly by water. By the route of the Rainy Lakes, and the old Grand Portage to Pigeon River, the article could be readily introduced into the basin of Lake Superior for mining and smelting purposes. The absence of coal and the deficiency of wood in that quarter, now drives its ores and metallic masses to very distant points to be smelted.

Washington, Dec. 9, 1854.

ART. XXIV.—*Abstract of a Meteorological Journal, for the Year 1854, kept at Marietta, Ohio;* by S. P. HILDRETH, M.D.

MONTHS.	THERMOMETER.							BAROMETER.		
	Mean temperature.	Maximum.	Minimum.	Fair days.	Cloudy days.	Rain and melted snow. Inches.	Rain and melted snow. Hund'ths.	Prevailing Winds.	Maximum.	Minimum.	Range.
January,	30·66	69	2	14	17	3	25	W. & S. W.	30·00	28·80	1·20
February,	37·66	59	14	19	9	2	33	S. W., S. & E.	29·80	28·80	1·00
March,	47·55	73	19	20	11	4	25	W. & N. W.	29·65	28·80	0·85
April,	49·66	85	22	15	15	5	42	W., S. W., N. E.	29·90	29·00	0·90
May,	62·50	95	34	20	11	2	12	S., N. & E.	29·75	28·90	0·85
June,	70·33	93	43	19	11	3	66	W. & N. W.	29·55	29·05	0·50
July,	76·66	98	56	28	3	2	04	S. W. & N. W.	29·60	29·35	0·25
August,	73·66	95	50	26	5	3	66	N. W. & E.	29·55	29·35	0·20
September,	69·96	97	42	24	6	2	16	W., N. W. & S.	29·88	29·12	0·76
October,	58·13	81	31	16	15	4	92	W., N. & E.	29·80	28·85	0·95
November,	41·33	66	22	17	13	2	29	W. N. W.	29·85	28·55	1·30
December,	32·22	55	8	13	18	3	00	N. W. & W.	29·70	28·90	0·80
Mean for the year,	54·20			231	134	38	80				

Remarks on the year 1854.

THE year just closed has been one that will long be remembered for several striking features; the most prominent of which were the long continued and excessive heat, accompanied by unexampled drought. No preceding year has witnessed such; embracing so vast an extent of country and so unremitting in severity. It ranged in longitude from the foot of the Rocky Mountains in the West, to the state of Maine in the East, and in latitude the region of country between the parallels of 32 and 42 degrees. In this space it was felt with the greatest severity; but varying somewhat in intensity, in different localities. The central portions of Iowa, Illinois, Indiana and Ohio seem to have sustained the focus of its force. Collections of water, and the courses of rivers, apparently ameliorated its destructive effects, by attracting occasional

showers along their borders. This was evidently so in the southern portions of Ohio where showers were so distributed as to produce good crops of Indian corn; especially in the vicinity of the Ohio and Muskingum rivers. In the hilly portions of the state, where the soil is argillaceous, and the ground not ploughed more than five or six inches deep, there was nearly an entire failure of this staple crop.

The superior advantages of deep and thorough tillage was never more strikingly seen than in the results of this year. The potato crop was a failure; as much from the excessive heat of the summer, as the drought; the tubers being in many instances partly cooked, becoming soft and spongy in texture. The result was the almost entire destruction of this important article of food, and raising the price to a higher figure than known since 1838, when the potato disease prevailed so extensively. The wheat crop was excellent over all the western states; having attained its growth before the severity of the drought commenced. In some districts the grain was entirely destroyed by insects; the wheat fly or miller (Tinea granella), a species different from the Hessian fly, or (Cecidomyia destructor) which attacks the plant in the culm, or stem near the ground; while the miller deposits its egg in the newly formed grain, and the larva eats and destroys the farinaceous portion, leaving only the cuticle, and the kernel an empty shell. If the season is cool the destruction is accomplished after the crop is reaped and stowed away in the stack or barn; but if the weather is quite hot, the mischief is done in the field, and thousands of acres this year, in the central portions of the state were left untouched by the sickle. The grass crop was good, attaining its growth before the want of rain was felt; but the pasturage in the latter part of the summer was a failure. Sweet potatoes, now an important crop in Southern Ohio, were less than usual in quantity, but of a most excellent quality. The long continued heat being congenial to their habit, and perfecting the saccharine portion of this delicious esculent, in an unusual degree. The fruit crop was rather a failure, small in amount, and inferior in quality. The heat changed winter apples into autumnal ones; causing them to decay at a much earlier period than heretofore.

The grape crop was less injured by the drought than almost any other; its greatest enemy was the Curculio; but yielded a fair average of fruit. As an evidence of the wonderful compensating power of Providence, in the laws which govern vegetation, by restoring the loss of one production in the increased amount of another, the natural fruits of the forest were unprecedented in amount and quantity. The golden age so much lauded by the ancient poets, seemed about to be again restored, in the immense quantities of acorns and other nuts. Many oaks being so loaded with fruit as to bend the branches nearly to the earth. On these

the hogs luxuriated and fattened, in a wonderful manner; so that many farmers, whose corn-fields returned nothing for their labor, had cause to thank God, for such an abundant supply of nutritious food in this season of scarcity. Hogs and sheep prefer nice white oak acorns to corn, as more agreeable to them, and fattening them full as certainly.

Temperature.—The mean temperature for the year is 54°·20, being an increase of 1·46 degrees over that of 1853, and 2 above the mean heat of this locality. From the long continued warmth of the summer and early autumn, we should be led to expect a higher rate than we actually find; but the seasons are so governed by the permanent laws of climate, that no very serious, or injurious changes can take place.

Rain.—The amount of rain and melted snow was $38\frac{39}{100}$ inches which is more than the excessive drought of summer would seem to indicate; showing also in this respect the permanency of the laws of distribution of moisture and the descent of aqueous vapor, that arises by evaporation from forests and the surface of the earth. The mean quantity for a year will probably remain nearly the same but may be differently distributed amongst the several months; less in summer and more in the winter and spring, requiring in some portions of the west the construction of reservoirs for irrigation during summer droughts, as is practiced in New Mexico and some countries in Asia. The Ohio river became unusually low by the last of June, so that navigation was much impeded. During the summer months and all the autumn, business on the river in a manner ceased, greatly to the loss of manufacturers and traders. Immense quantities of iron and coal lay piled up on the banks of the Ohio, until the ice closed the river, early in December. Flat boats with produce could not float to their usual markets below; the yards of dealers in coal and fuel were exhausted in the cities and towns that depend on navigation for a supply and great suffering was the consequence of this low stage of water for so long a time.

Winter.—The mean of the winter months was 33°·13—which is rather mild. The mercury sunk to 8° above zero in December and to 2° in January, which were the extremes. During this season there fell about nine inches of snow, at different times; the greatest fall being not over six inches. It was a singular fact that the deepest snow, eight inches, fell on the 17th day of April; and at head waters about Pittsburg, over a foot. Also on the 29th of the month at Marietta, four inches, a very rare occurence.

Spring.—The mean temperature of spring was 53°·24, which is above the average. The supply of rain was abundant, being nearly twelve inches, or about one-third of the amount for the whole year. In April there fell with the melted snow five and a half inches, furnishing a liberal supply for the growth of early crops, such as grass and wheat.

Summer.—The mean of the summer months was 73°·55, which is three degrees above the mean average, but only one degree above that of the last year, which was very hot. There was some change in the distribution as to months, June having only 70°·33 this year, and 74°·60 in 1853; while July in 1854, had 76°·66, in place of 71°·15, in the preceding year. August varied less; being 73°·66 in place of 71°·55. During some of the hottest days in July, the temperature was 98° on the north side of my house, protected by the shade of a tree; and 140° in the direct rays of the sun. Under thick shady trees it rose to 100°, and continued all night above 90°, in the dwelling house, in several places. "Hot enough to roast eggs," is an old vulgar saying. I tried the experiment—a common hen's egg was painted black, put in an iron vessel and placed in the rays of the sun at noon. In two hours the white was cooked quite thick—the yolk in the centre not much changed. An acquaintance of mine blistered the ball of his thumb by picking up a small iron bar, that had been lying in the sun's rays. Many fields of late planted corn were much damaged by the heat of the sun scorching the leaves on the S. W. side of the hills, and killing the pollen of the blossoms, so that the silks could not be impregnated, rendering the grain abortive.

Autumn.—The mean temperature of autumn was 56°·50, which is nearly three and a half degrees higher than in 1853, and above the annual average. It arose from the heat of September 69°·96, which is nearly ten degrees above that of some years, and six above the mean for this month. The severe drought continued into the autumn, cutting off the fall crops of turnips, cabbage, &c. The yield of Indian corn was much lessened in amount, but bore the drought better than any other grain. It is the first year since the settlement of the state, which has threatened an entire failure of this staple crop. It is one, the loss of which, would be more injurious to the inhabitants than that of wheat; as it affords sustenance to both man and beast, and is the source from which that immense quantity of beef and bacon is supplied. It is supposed that the amount in the valley of the Ohio is fully one-third less than the average.

Floral Calendar.—February 8th, Robin seen; 10th, Bluebird; 12th, Honey bee abroad.

March 12th, Hepatica triloba in bloom; 15th, Early Hyacinth, Peach ready to open; 24th, Crown Imperial ready to bloom; 27th, Blackbird in flocks; 30th, Pyrus Japonica in bloom.

April 1st, Crown Imperial open; 2d, Hyacinth in full bloom; 4th, Martin seen, Primrose in bloom; 5th, Sanguinaria Canadensis; 6th, Spirea Prunifolia; 7th, Peach tree; 9th, Pear and Plum; 14th, Dodecatheon; 17th, Snow eight inches deep in the woodlands; 18th, Pear blossoms full of melted snow and frozen.

Thermometer at 26° and yet there was fruit; 21st, Apple tree in bloom; 24th, Chimney Swallow appears; 25th, Harebell; 29th, Four inches of snow fell; 30th, Lilac in bloom.

May 1st, Quinces and Cornus Florida; 3d, Papaw; 4th, Black Haw; 12th, Red Peoney; 13th, Yellow Rose; 16th, Weigelia rosea; 17th, Syringa fragrans; 21st Locust tree; 25th, Early strawberry ripe; 27th, Antwerp raspberry in bloom; 28th, Bulbous Iris; 30th, Syringa Philadelphica; 31st, Roses generally in bloom.

June 29th, Catalpa in bloom.

Art. XXV.—*On the Composition of Eggs in the animal series;* by A. Valenciennes and Frémy.—Part II.*

We referred in our first article, to the observations made previously on birds' eggs. Taking these eggs for criterions, we exhibited the results of our researches on those of cartilaginous fishes of the family of Squalidæ (Sharks,) and of those of the Raiidæ (Rays). We remarked that the white shows hardly any traces of albumen, and that the yellow contains a substance insoluble in water, suspended in the liquid in small tables, of forms varying according to the species; we explained its characteristics and its composition, and we called it *Ichthin*. We continue the explanation of our researches on the eggs of animals, completing what we have to say of other kinds of fish.

Of the Eggs of the Osseous Fishes.

The larger number of osseous fishes are oviparous. The ovary and the oviduct are in one large common sac, rounded toward the top, narrowed toward the bottom, and enveloped in a fold of the peritoneum, which the anatomist can separate from the real membrane of the passage of the ovario-oviduct, these two oblong pockets are reunited a little before their exit, behind the rectum. Each organ is suspended above from the intestines by a ligamentary fold of the peritoneum. The lower portion of the abdominal region of this sac is smooth and without any fold of the membrane. On the upper or dorsal part, there are numerous scales, or lobes on which there are developed, in their own capsules, the thousands of ovulæ afterwards to be laid. These ovarian folds are divided and subdivided into secondary, tertiary, and quaternary lobes of forms differing with the species. They float in tufts and bunches, and in developing themselves, become those familiarly known masses of eggs. When the ovula is ripe, (to make use of the technical word,) it detaches itself from its ovarian capsule, it falls into the lower or oviduct portion of the sac,

* From the Journal de Pharmacie, &c., June, 1854, p. 415.

and after staying in this oviduct a long or a short time, it changes its nature there, and then it is laid in places along shores, sandy or rocky, in kinds of nest chosen or arranged by the instinctive faculties of the mother; after which it is hatched. As to the ovula or the egg changing the composition of its liquids during its stay in the oviduct:—this ovula while still shut up in its ovarian capsule, is more or less opaque, on account of the fat which it contains. Detached, it becomes transparent, the yolk surrounded by its albuminous matter is clearly visible, unless its vitellin membrane be of appreciable thickness, and the ichthulin of which we shall soon speak, is replaced by albumen. Thus the egg which shows only some traces of albumen when still attached to the ovary, becomes very albuminous when it is free in the oviduct. In the larger number of fish, the ovary is double. We have spoken of the prodigious number of eggs layed by some of them, and we could cite numerous examples. The number increases in proportion to the size of the females and the smallness of the eggs. As they are almost all of the same weight and size, we weigh the ovary and by counting the number of eggs in a gramme, we can estimate pretty closely, the entire number developed in the ovary. It is in the thick-lipped Grey Mullet (*Mugil Chelo*, Nob.) that we have found as yet the greatest quantity. One of this species of the length of $0^{m}{\cdot}60$, contained 13,000,000 eggs; a Codfish (Gadus Morrhua, *Lin.*) of one metre, gives 11,000,000; a Turbot (Pleuronectes maximus, *Lin.*) of $0^{m}{\cdot}50$ length, lays 9,000,000; we estimated 6,000,000 in a Plaice, (Pleuronectes maximus, *Lin.*) of the length of $0^{m}{\cdot}30$; the carp, whose eggs are the largest, gives only 600,000 or 700,000, when from $0^{m}{\cdot}15$ to $0^{m}{\cdot}50$ long. Other fish with only a single ovary, have a much smaller number of eggs, than those named. Having made an estimate on a dozen large perch of the rivers in Holland, Belgium, Picardy, and the neighborhoods of Paris, we found for a mean 71,000 eggs; Bloch gave nearly twice as many. We discovered in the eggs of the osseous fishes immediate principles entirely different from the ichthin of rays and sharks. The study of carps' eggs enabled us to appreciate these differences.

Carps' Eggs.—On studying under the microscope an ovula of a carp slightly advanced, it is seen that the liquid holds suspended in it a number of little drops of fat slightly colored, in the midst of which are to be seen swimming transparent granules, tabular in form, which recall those of the vitellus of the ray. The China *Dorado*, vulgarly the *Redfish*, (the Sea-bream, Cyprinus brama,) is another species of carp whose ovules present similar small grains mixed with drops of oil.

Ichthidine.—In spite of their resemblance in form, the granules of which we speak, are not formed of ichthin; for in treating the ovula crushed from a carp with a small quantity of water, the

grains gradually decay and in a few minutes entirely disappear. The substance which constitutes them is then soluble in water, while ichthin is insoluble. Admitting, for a moment, that these grains are formed of ichthin, their solubility might be attributed to the action of the albuminous liquid existing in the carp's egg, which would thus show the property of dissolving the ichthin of Rays. To verify this hypothesis, we introduced some grains of ichthin from a ray into the liquid of the crushed eggs of a carp; the whole was submitted to the action of water. We then saw the granules of the carp's eggs gradually disappear; those of ichthin were not altered by the water. It thus seems to be demonstrated that there exists in the eggs of certain Cyprinidæ, a substance soluble in water, which presents itself in the form of rectangular grains. Although it has been impossible to give to this observation all the exactness desirable, for the soluble grains could not be isolated, yet we think we ought, while waiting for more satisfactory results, to give a name to this substance, and we propose that of *Ichthidine*. When we employed saline solvents, these grains always disappeared in the washings. Besides, the presence, in these eggs, of a body which we are about to describe, made this separation still more difficult.

Ichthulin.—We have just said that a small quantity of water mixed with the liquid obtained by crushing carps' eggs, in process of formation, made the rectangular grains of ichthidin disappear, and that it produced a transparent liquid, holding nothing suspended but a few grains of fat. By increasing the proportion of water, a new body immediately is seen in precipitate, which till then was in solution in the albuminous liquor, and which collected by being agitated, separates in the shape of a syrupy, ropy mass, insoluble in water. This substance is found in a large number of the eggs of birds which we have been in the habit of examining while they were in the state of ovulæ, retained in the ovary. We have established its presence in the Labrax lupus, the thick-lipped Grey Mullet (Mugil Chelo, *Nob.*), the Mackerel (Scomber Scombrus, *Lin.*), the Turbot (Pleuronectes maximus, *Lin.*), the common Sole (Pleuronectes Solea, *Lin.*), the Breton Sole (Solea armorica, *Val.*). We have established its existence, and in great abundance too, in the eggs of Salmon, already detached from the ovarian lobes, and fallen into the abdominal cavity. It seemed to us at least important to study it carefully, and to ascertain its composition. We have given it the name of *Ichthulin*. The liquid obtained by pressing the eggs of Salmon in a cloth is treated with distilled water, the albumen dissolves, and the precipitation of the ichthulin is effected. This substance is then purified by being washed with alcohol and ether.

At the moment of its precipitation the ichthulin is viscous and resembles gluten. But the action of the alcohol and ether causes it to lose its viscosity, and it becomes then solid and powdery. The ichthulin, which in its physical properties differs in every respect from ichthin, is very like it in its chemical characteristics. It is, like the latter, soluble in acetic and phosphoric acids; it dissolves too in hydrochloric acid, without producing a violet color. Its composition is as follows:

I.		II.	
Solid matter,	0·283	Solid matter,	0·253
Water,	0·205	Water,	0·190
Carbonic acid,	0·545	Carbonic acid,	0·495
Proportion of Azote.			
Solid matter,	0.338		
Azote,	0·05145		
Per centages.		*Per centages.*	
Carbon,	52·5	Carbon,	53·3
Hydrogen,	8·0	Hydrogen,	8·3
Azote,	15·2		
Phosphorus,	0·6		
Sulphur,	1·0		
Oxygen,	22·7		

From these analyses it follows that ichthulin differs in composition from ichthin: it approaches on the other hand that of albumen, and like it, contains sulphur and phosphorus. From these facts, it follows that the eggs of fishes of the family of Cyprinidæ, when only a little developed, contain, with a soluble substance ichthidin, a liquid strongly albuminous holding in solution mineral salts, some ichthulin, and suspended in it phosphoric fat. After obtaining these results, it seemed interesting to compare with eggs in the state of ovulæ the composition of eggs of the same sort completely formed, detached from the ovarian lobules and free in the oviduct. This examination has brought us to the establishment of this very important physiological fact: that is, that the composition of eggs undergoes, with the age of their development, important modifications, even before the laying, and during the time that they remain in the oviduct. It is in fact, a result of our analyses, that the eggs of the Carp, entirely formed, contain no longer traces of ichthidin; that the ichthidin gradually disappears, and that when they are become entirely transparent, these eggs are formed wholly of a liquor strongly albuminous, which holds suspended in it phosphuretted fat. The examination of Carps' eggs while young, has also shown us, that to study the eggs of these Cyprinidæ, it is necessary to guard against putting them in contact with water, which often dissolves bodies whose presence it is important to establish, and which in other cases, precipitates substances as the ichthulin, which were at first dissolved in it.

Perfect eggs (œufs mûrs) of the Mullet, Trout, Pike, Whiting, Plaice, Sole, and the Dab.—We have continued our former researches on the different fishes above named, taking care to profit by the season for spawning. We found in the ovary of the Plaice and Pike, and of the others, eggs entirely formed, not containing ichthidin at any period of their development, but very rich in ichthulin in their early age. Detached from the ovary, and free in the oviduct, they no longer showed us the least trace of ichthulin; they then consist of a very albuminous liquid, containing a considerable quantity of phosphuretted fat. This quantity of albumen explains why the eggs of all these kinds of fish become hard by boiling.

Eggs of Salmon.—Salmon's eggs do not contain rectangular grains soluble in water. Those which we have examined were free in the abdominal cavity, they contained much of ichthulin and very little albumen. Their color, reddish yellow, is due to the presence of a considerable quantity of phosphuretted oil. Submitted to the process of boiling, they become opaque, but remain always soft, even if kept a long time in boiling water. This is easily understood, since they have only a very slight amount of albumen. Their opacity is caused by the water brought into them, which thus stops the precipitation of the ichthulin.

Eels' Eggs.—The eggs or rather the ovulæ of the eel, taken in fish kept in fish-ponds are much too small to enable us to make researches of any extent on these curious productions of the organs of generation. We have been able however, to assure ourselves that they contain perhaps still more fat than the eggs of Salmon, and they do not seem to have more albumen, for they do not harden by boiling. We have not been able to see in them the least trace of ichthidin. Our researches supply a very simple method of observing the eggs of the eel. It is sufficient to boil for a few minutes one of the ovarian lobules: then the eggs swell without hardening, the distended membranes become more apparent, and with sufficient enlargement, one easily sees the ovulæ which are hardly one or two hundredths of a millimeter. If, as we do not doubt, our further observations confirm those which we now publish, we will thus give an easy method, and a sure one too, to ascertain whether the female has kept its eggs long enough in its oviduct to perfect them, and whether they are in a condition to be productive. It will suffice to take a few from the body of the fish, to crush them on a glass-plate, and to add a little water. If there is no precipitate of ichthulin, the egg is perfect, for it only contains albumen and phosphuretted fat. If ichthulin is precipitated, it will be necessary to restore the fish to the water, and to wait awhile before proceeding to fecundation. We point this out as the most certain method, to persons who wish to try artificial breeding.

After having established that the eggs of fishes contain substances insoluble in water, ichthin and ichthulin, which have both of them, properties different from the vitellin of birds, we have inquired whether the albumen of fishes' eggs is the same as that of birds' eggs. Although we reserve the detailed account of this examination for a succeeding memoir, we are prepared to affirm that these two albuminous substances often present in their properties notable differences. In fact, the albumen of the eggs of certain fishes dissolves without any discoloration in hydrochloric acid, and it begins to coagulate at about 45° ; while the albumen of birds' eggs, dissolves, as we know, in hydrochloric acid, and gives to the liquid, a violet-blue color, and it does not coagulate below 63°. Are these differences sufficient to admit really, in the animal organization several sorts of albumen? Can the blue color produced by hydrochloric acid, be considered as a specific characteristic of albumen? In short, may not the mineral salts contained in the albumen in different proportions, exercise an influence on the point of coagulation of this substance? These are delicate questions whose importance we appreciate, and which we shall treat in a special article to be devoted to albuminous substances.

(To be concluded.)

ART. XXVI.—*Chemical Examinations;* by EZEQUIEL URICOECHEA, of Bogota.

1. *Chemical Examination of the Oloba, and of a new body, Olobile, contained in it.*

The Oloba, a fat, has been known in New Granada for a very long time, and I have no doubt that the aborigines were the first to use it, for we know well that they used the palm-wax for illumination, as Pedro Ciezor De Leon* tells us.

The tree which produces it is the Myristia Oloba† of about 20 meters height. It grows in the warm valleys of New Granada, and only there, for all the efforts to plant it in the table-land of Bogota, have been unsuccessful. Bonpland found the tree in Mariquita, west of the River Magdalena, a place well known for its silver mine.

The use of Oloba is to my knowledge, exclusively, in veterinary medicine, especially in the cure of skin complaints with horses, for although Garcia de Alonzo‡ made in 1808 some experiments with reference to using it for illumination, I believe nobody has followed them up.

* Cronica del Peru, Part I.
† Humboldt et Bonpland, Plantes Equinoxiales, tome ii, p. 8.
‡ Semanario de la Nueva Granada, (2d ed.) 1848. p. 341.

Playfair examined the well known Mochat butter, and discovered the myristic acid in it. It was very probable that in the butter obtained from another plant of the same genus the same constituents were to be found. Having received, however, some Oloba, direct from New Granada, I determined to examine it. When fresh, the Oloba exhales, on being melted, a very unpleasant odor owing to a volatile oil. The quantity that I received, however, had lost a good deal of this peculiar odor.

The Oloba was seen at once to be composed of different fats, a white one and a brownish-red, which although in close contact, irregularly disseminated through the mass, could easily be distinguished from one another.

To free it from impurities it was melted and filtered through a fine cloth, on which it left pieces of palm leaves, and a brownish-red mass (pollen?) which undoubtedly gave the coloring to certain portions of the Oloba. On cooling, the Oloba presented a crystalline texture and a yellowish-white color. Its melting point was 38°*. A determination of the melting point of the impure Mochat butter gave 51°, a difference from that of the Oloba which I cannot explain.

The Oloba, freed from all visible impurities by filtration, was boiled with a solution of caustic soda until every oily appearance had disappeared from the surface of the liquid. This was diluted with some water and common salt thrown in, in excess, so that after cooling, the soap, rendered insoluble, could be easily separated from the liquid. This was evaporated nearly to dryness and in the usual way the presence of glycerine proved, by its sweet taste and its acrol reaction. The soap was dissolved once more in water and decomposed by hydrochloric acid. The fat acids were melted again twice in boiling water to free them completely from the hydrochloric acid, and after cooling the second time, they were dissolved in alcohol.

A portion of acetate of magnesia equal to a twentieth part of the weight of the acids was taken, and after being dissolved in alcohol, mixed with the solution of the acids. By this process only a part of these acids could combine with the magnesia, those of course being the first to unite which have the strongest affinity. This is a very easy way of separating the fatty acids, and has been called "the method by fractional precipitation." After the first precipitation was completely separated, in this case always as crystals, it was filtered and into the filtrate another portion of acetate of magnesia in solution was thrown. This was repeated until the magnesia salt gave no precipitate even after standing for a long time in a cool place. Then acetate of lead was substituted; and when this, employed in excess, produced no more change, ammonia was added. In this way the different acids were sepa-

* The Centigrade scale is to be understood through this paper.

rated. I examined, however, only that one which was combined with the magnesia, the lead salt being left, for want of time, for a future examination.

The magnesia salt which fell from the alcoholic solution was decomposed by hydrochloric acid, and the fatty acid after being crystallized two or three times from its alcoholic solution had a constant melting point at 53°. Playfair gave as the melting point of myristic acid 49°, but Heintz in his masterly examination of the spermaceti* obtained for the melting point of this acid 53°·8, with which, my own observation, made before Heintz's article was published, agrees very well.

To be sure of the identity, an elementary analysis was made.

0·4275 gram. of substance gave 1·152 gr. of carbonic acid and 0·4750 gr. of water, or

	At.	Calculated.	Found.
Carbon,	28	73·68	73·50
Hydrogen,	28	12·28	12·34
Oxygen,	4	14·04	14·16
		100·00	100·00

The analysis as we see, agrees exactly with the formula $C^{28}H^{28}O^4$ which Playfair gave for myristic acid, and which Heintz has recently confirmed.

In the first and sometimes in the second of the partial precipitations another substance is found which I have named Olobile (Oloba and ὕλη.)

It is less soluble in alcohol than myristic acid, but more readily so in ether; these particulars, and its crystallizing out first from a mixed solution are properties by which a separation from myristic acid is easily effected.

It crystallizes in beautiful (square?) prisms, colorless, transparent, and with a strong vitreous lustre. Melts at 133°; on cooling a few degrees, it solidifies to a crystalline mass; and on heating again the melting point remains the same. This reaction is so very different from that of Olivile, that it suggested at once the supposition that this was a new body.

Two elementary analysis were made in order to test this conclusion:

1. 0·2804 gr. of Olobile gave 0·7524 of carbonic acid and 0·1603 of water.

2. 0·1793 gr. of Olobile gave 0·4801 of carbonic acid and 0·1027 of water, or

	I.	II.
Carbon,	73·19	72·86
Hydrogen,	6·35	6·46
Oxygen,	20·46	20·68
	100·00	100·00

* Pogg. Ann., vol. xcii, p. 441.

Which leads us to the formula $C^{24}H^{13}O^{5}$;

		Calculated.	Mean of I. and II.
Carbon, - -	24	73,09	73·02
Hydrogen, - -	13	6·59	6·41
Oxygen, - -	5	20·30	20·57
		100·00	100·00

proving it to be a new body. For want of material, I have not studied the products of decomposition, which, no doubt, are analogous to those of Olivile, and no other reactions except its solubility in ether and alcohol, insolubility in water, melting point at 133°, and its non-volatilization were noticed. I hope after returning to Bogota, to study it further. Meanwhile this examination may do something towards giving a knowledge of a plant, so much used and apparently so beneficial at home. This first result obtained by me, is that Oloba contains a volatile oil, a fixed one, myristic acid in combination with glycerine, and Olobile.

2. *Analyses of two Gold Idols of the Aborigines of New Granada.*

My studies on the antiquities of my country, the result of which I have laid before the public,* gave me occasion to make analyses of the gold idols in my possession.

It is impossible to tell their age; yet it is certain they were made before the Spaniards conquered the country. The exact locality also is unknown, although they were sent to me from Bogota; but there is very little doubt that they were made by the Chibcha nation (called also Muiscas) and among them, the tribe which was known under the name of Guatavita, and whose inhabitants were renowned for working in gold.

We know of the lake Guatavita, that for ages, millions of gold idols were thrown into it as offerings to the gods in time of need. We also know that a powerful cacique every year entered the lake, bathed in turpentine and gold dust, and in the middle of it, after throwing in the largest amounts of gold, he himself followed the gold into the waters where they had disappeared, and bathed; which story gave the name "El dorado" to our country. The Indians of this nation then, were the gold sculptors, and the alloy they mixed was the one I examined.

The external color of the metal of these idols is different; some are light yellow and others copper-red. On heating the alloy it blackens at a red heat, becoming covered with the black oxyd of copper. On washing it with hydrochloric acid, the color becomes yellowish white, probably by the formation of chlorid of silver; for by washing it again with ammonia it becomes copper-red.

* Memoria sobre las Antiguedades Neo-granadinas. Berlin, F. Schreiber & Co., 1854.

The analysis of such an alloy is so simple that I need only give the results.

	I.	II.
Gold,	54·63	45·91
Silver,	16·31	10·55
Copper,	29·31	43·70
	100·25	100·16

All the analyses that we possess of native gold from New Granada* give no copper; which makes us at once suppose that the aborigines knew the art of alloying, for they could find copper in the native state in several parts of New Granada as for examples in Moniguirà.

It is difficult to say how they could use coins without any stamp, merely round plates of gold, while they know how to alloy metals, for undoubtedly great frauds could be made. Acosta however, is of opinion that the Chibchas had the gold plates for curreney and were the only American aborigines that made use of the metal, as coin, in their exchanges.

ART. XXVII.—*Review of the Fifth volume of the Agriculture of New York, &c., by E. Emmons.*†

'Ignorance *per se* is not a crime, its heinousness depends upon the use which is made of it.'—*American Journ. Sci. and Arts.*

THIS volume purports to contain descriptions of the more common and injurious species of insects found in "New York and New England." It contains 256 pages of text, and 50 plates, 47 of which are colored.

The text, as is intimated in the preface, has been mostly collected from the researches of others, and in truth, in the descriptive portion of the work, brief specific phrases alternate with excerpts from the synopsis of British genera at the end of Westwood's Introduction to the modern classification of insects.

However applicable these diagnoses may be in British Entomology, it may be doubted whether they can be used with advantage in a country where a large number even of common insects belong to genera not found in Britain, or whether it was necessary to copy from foreign works, when there are men of ability in the land who could have given original and accurate descriptions. We feel assured that a small compensation compared with

* Dana's Mineralogy, and Coleccion de Memorias cientificas por Joaquin Acosta. Paris, 1848. p. 43–50.

† NATURAL HISTORY OF NEW YORK: *Agriculture of New York*, comprising an account of the classification, composition, and distribution of the Soils and Rocks and of the climate and agricultural productions of the State, together with descriptions of the more common and injurious insects; by E. Emmons, M.D. Vol. V. Albany, 1854. The volume is devoted to the last topic, "The Insects of New York."

the money which has been expended on the volume before us, could have secured an original memoir, that would have been useful both to the scientific student and to those seeking for information in a popular form.*

The plates contain figures of many of our common insects of each order. The figures are in general recognizable, but the execution is disgraceful. The references are frequently confused and more often imperfect, even for the most common species.

As the plates appear to be the most important part of the book, and a review of the whole would be tedious, we will begin by mentioning some of the important errors conveyed by the figures of Coleoptera. To go through the other orders would require more patience than can be properly claimed either of our readers or of ourselves; moreover, as the order of Coleoptera has been better studied than any other, and information regarding it is more accessible to both the student and the compiler, a glance at the part of the work devoted to it will probably enable us fairly to appreciate the method pursued by the author.

Pl. 2, fig. 8, '*Clerus apiarius*.' The name belongs to a European insect; the figure if not copied from a European work, may represent our somewhat allied Trichodes apivorus *Germ.*

Pl. 5, fig. 2, '*Buprestis dentipes*' is B. punctulata *Sch.* (transversa *Say*), and belongs to the genus *Dicerca;* B. dentipes *Germ.* is a *Chrysobothris.* Fig. 8, '*Buprestis* ——' is an Elateride, not noticed in the text. Fig. 10, '*Dyticus Harrisii*' is D. verticalis *Say.*

Pl. 8. The very abundant *Clytus colonus* is queried; while *C. erythrocephalus* is left unnamed: fig. 4, of the reference is marked 5 on the plate, while 4 is omitted: we thus have 13 references to 12 figures. Fig. 9, '*Elaphidion*' is irrecognizable.

Pl. 10, fig. 5, '*Scarites* ——' is the very common *Passalus interruptus*, and is noted among the corrections (p. 256) as "allied to Sinodendron," but its name is not given.

Pl. 11, fig. 3, '*Coccinella 12-notata*' is Hippodamia convergens *Guérin.* Fig. 11, '*C. binoculata*' is (text, p. 137) described as C. trioculata: the description of *C. binotata*, p. 138, we may remark in passing, is altogether wrong.

Pl. 12, figs. 10 and 11, '*Platycerus piceus*' in recent times is placed in the genus *Ceruchus.*

Pl. 14, fig. 5, '*Chrysomela tremula.*' Why is this European species introduced into the Natural History of New York? It has been frequently figured in its own country.

Pl. 14, fig. 4, '*Galleruca* ——' is the well known Galleruca (Diabrotica) 12-punctata: in the text, p. 129, it is noted as Crioceris

* Even a few plates added to Dr. Harris's admirable treatise On the Insects of Massachusetts injurious to Vegetation, would have given to the farmer, as well as to the scientific observer all the necessary information regarding our injurious species.

12-punctata, and on p. 134, reappears as '*Adimonia* ——'. Immediately following the description p. 134, is placed *Lema trivittata*, thus putting it in a group to which it does not belong. Per contra, the same insect appears on page 129, as 'Crioceris (or Lema) trilineata (Oliv.).

Pl. 17, fig. 6, '*Cicindela campestris*' is C. 6-guttata; we are at a loss to understand the motive for introducing the European C. campestris in a Zoology so well provided with species of the genus. If another figure was wanted to fill up the plate, there are several American species well worthy of the place.

Pl. 17, fig. 14, '*Cicindela* ——,' is the well known C. unipunctata, but probably, to quote the words of a former collaborator on the Survey, is 'extra-limital.'

Pl. 17, fig. 15, '*Cicindela?* (*Maryland*),' is Megacephala virginica, and is so noted in the corrections on page 257, with many others not introduced in this review.

Pl. 19, fig. 9, '*Anisodactylus agricollis*' (!!)

Pl. 20, fig. 8, '*Chlænius lithophilus*.' Particularly bad, if it be the species intended.

Pl. 20, fig. 11, '*Omophron labratum*' is O. americanum *Dej.*, and fig. 12, 'var. tesselatum', is nothing like O. tesselatum *Say*. The forms are strangely caricatured.

Pl. 21, fig. 4 '*Lampyris ungulata*' should be L. angulata, and fig. 5, '*L. scintillaris*' ought to be L. scintillans: neither fig. 7 or 8 belong to Dictyoptera, but if not placed in Digrapha, they should have been left where they were found, in Lycus.

Pl. 21, fig. 9, '*Dicælus dilatatus*,' and fig. 13, '*D. elongatus*.' These have been reversed in some way: the references in the text (p. 49) are right. Fig. 10 is anything rather than Sphœroderus stenostomus.

Pl. 23, in two places we find *Necrophagus* for Necrophorus.

Pl. 25, fig. 3, '*Platycerus piceus*;' for another insect under the same name, vide pl. 12; fig. 5, '*Osmoderma scaber*' seems intended for O. eremicola; fig. 6, '*Pyrochroa flabellata*' is very bad, while fig. 8, '*Upis pennsylvanicus*,' represents nothing found in the country.

Pl. 31, fig. 1, '*Cantharis atrata*' is a duplicate of pl. 25, fig. 4. Each figure appears to be worse than the other, but the strongest impression is left by the one last looked at. Can fig. 4 be '*Onthophagus Hecate*'? Fig. 8, '*Hister conformis*' is H. abbreviatus *Fabr.* '*H. conformis Dej.*,' belongs to the genus Saprinus, and was described and figured in the Boston Journal of Natural History, so that no excuse can be offered for the confusion. Fig. 10, not '*Tenebrio molitor*,' but a species of Iphthinus; fig. 13, '*Copris* ——' is C. anaglyptica *Say*.

Pl. 34, fig. 1, '*Podabrus modestus*' is Telephorus carolinus. What can fig. 2 be? It is marked '*Stenocorus cinctus*,' but the resemblance is not apparent. Fig. 3, '*Telephorus* ——' is Nacerdes melanura, an Œdemerite described by Linnæus, found in all our cities, and now carried by commerce from Europe over the greater part of the globe. Fig. 7, '*Saperda* ——' we have already had on pl. 16, as S. calcarata. Fig. 8, '*Monohammus pusillus*' is Graphisurus fasciatus. Fig. 9, '*Cerambyx* (undescribed)' is Dorcaschema nigrum, long ago described by Say. Fig. 11, '*Leptura* ——' is Toxotus cylindricollis *Say*, also a well known species.

Having thus mentioned some of the more conspicuous errors in the plates, and referring for others to the list on page 257 of the text, we may now turn our attention to that portion of the work.

It is, as was stated before, mostly made up of extracts from other works; with what skill these are placed together will appear shortly. In the mean time we regret to be compelled to call attention to the fact, that while on page 25, it is stated that the anatomical figures have been copied mostly from the Naturalists' Library, we find the plates (A, B and C), on which these figures appear, credited to E. Emmons, Jr. Could not the lithographer be trusted to make the copies? Why should the expense of repeating the drawings be thrown on the State? That under a liberal grant from the Legislature, such as has been expended in the New York Survey, our entomology should be illustrated by copies of foreign figures of foreign species is at least discreditable; but what can be said, when an author permits a person in his employment, to affix his name to these foreign labors?

Continuing our exposition of errors, we find that on page 31, the reader would be inclined to believe that Mr. McLeay has divided all *beetles* into 1, Geodephaga and 2, Hydradephaga: this is not so.

Page 35, for '*Cicindela guttata*' read C. sexguttata.

Page 39, Div. 5 of Carabidæ, '*Bembidiides*' are placed under those having the 'anterior tibiæ without a notch near the tip': on page 53, a contrary statement is made, that 'the anterior tibiæ are always notched on their insides near their tips.'

Page 41, the explosive power characteristic of Brachinus and closely allied genera, is here extended to the whole section of Brachinides as defined by Westwood.

Page 42, '*Polystichus* (Bar.)' is placed as a synonym of Galerita, and the description of the former copied from Westwood. Polystichus was never applied to North American species, but was established by Bonelli (not Bar.) upon certain small European insects, previously placed in Galerita.

The system of arrangement pursued by the author, will be better illustrated by an example, than by any criticism. Com-

mencing therefore with the genera of Harpalides (p. 45), the succession is: Agonum, Harpalus, Pangus, Amara, Agonoderus, Anisodactylus, Chlænius, Trechus, Calathus, Anchomenus, Dicælus, Sphæroderus. Then comes the family Carabides with Cychrus, &c.

Many of the genera are not described; when descriptions are given they are, as frequently as possible, taken from Westwood's synopsis above mentioned: this however can be done only with genera found in Britain; for the rest we have sometimes, as in Galerita, a misapplication of a description of an allied genus, or occasionally an original description; as a specimen of the latter, we will take Agonoderus (p. 47). "Head subquadrate, thorax subquadrate, slightly narrowed behind, elongate: the thorax equals in width the base of the elytra.

Page 55, we have 'Dyticus' ranked under Haliplides.

Page 60, '*Dermestes lardarius*' is placed in the family Cucuiides.

Page 61. The generic description of *Staphylinus* fails in two of the three species placed under it: the one to which it applies, S. cyanipennis, is not a Staphylinus, but a *Philonthus*.

The names of authors are usually omitted, references to their works under synonyms or names are never given. Where the authorities are mentioned, '*Anchomenus extensicollis* (Steph.)' and '*Necrophorus pygmeus* (Rich.), show what reliance may be placed on them.

The genera of Lamellicornes have been arranged on the same principles as the Harpalides already cited. The succession (p. 67) is; Geotrupidæ, Geotrupes, Coprobius; Scarabæides, Onthophagus, Phanæus, Aphodius, (with a remark on Lethrus cephalotes,) Copris. The parallelism of the results is further illustrated by the description of Coprobius, which being an American genus is not found in Westwood. "Body ovoid; thorax dilated in the middle, scutellum none: abdomen nearly square, clypeus bidenticulated;" this will compare favorably with Agonoderus above.

But it is time to stop. Although we have gone over but a very small portion of the volume, our readers have had enough to enable them to judge of the character of the work. The task of the reviewer is a thankless one; but if it will prevent books of like merit or rather demerit from appearing in future 'by authority,' it has not been performed in vain. Indignant protests from students of Entomology, should at once dispel the illusion, if such there be, that this volume is an exposition of the present condition of their science in this country. We write in earnest, because we feel that great interests have been sacrificed, American science injured, and a very poor return given for the honest confidence of employers. J. L. L.

ART. XXVIII.—*Caricography;* by Prof. C. DEWEY.

(Continued from vol. xviii, p. 104, Second Series.)

No. 246. *Carex lucorum*, Willd., Kunze Suppl., No. 47, fig. 39, non Sart., Car. Am. Sept. Exsicc. no.

Spica staminifera unica; spicis pistilliferis 2–3, subglobosis, sessilibus, bracteatis; fructibus *tristigmaticis*, ovatis vel subglobosis, subtriquetris, pedicellatis, hirtulis, nervosis, prolongo-rostratis, bidentatis, squama ovata oblonga acuta sublongioribus.

Culm triquetrous, slender, erect and subscabrous on the angles; leaves narrow linear, scabrous on the edge; fertile spikes two or three and sessile, ovate and few-flowered; stigmas three, and very long; fruit oviform, tapering below or stipitate, rostrate above, two-toothed; the beak large and about half the length of the whole fruit, and deep-split; pistillate scale ovate, oblong and acute or ovate-lanceolate, a little shorter than the fruit.

Kunze remarks the resemblance of this species to *C. Pennsylvanica*, Lam., and to *C. marginata*, Schk. It has the same reddish scales, but is easily distinguished by the peculiar shape of the fruit and the beak.

As this species is very distinct, and should be recognized by our botanists, I have derived the preceding description from Kunze for their benefit. The plant has probably been confounded with *C. emarginata*, Schk. Kunze states that it was raised from American seed in the Botanic Garden at Berlin, and afterwards the plant also was received from a collection made by Rugel at Bergen on Broad River, North Carolina, May, 1841.

Though I labelled some specimens, a few years since, by this name, I am not confident of their identity with this species of Willdenow. The fruit of *C. nigromaginata*, Schw., is too unlike that of this species as given by Kunze.

NOTE.—*C. marginata*, Muhl. and Schk., has been considered to be *C. Pennsylvanica*, Lam. The former was described in vol. xi, p. 163, First Series, and the latter referred to it. A more extensive comparison of specimens over our wide country from New England to Kansas Ter., has led me to conclude there are two species under these two names, manifestly distinct. As the one has been described, as above, the other is here given.

No. 247. *C. Pennsylvanica*, Lam. Encycl.

Spica staminifera unica cum squamis oblongis obtusis; pistilliferis 2–3, ovatis, sessilibus, inferiore bracteata, fructibus *tristigmaticis*, oblongo-ovalibus vel ovato-oblongis, trinervosis, subtriquetris, brevi-rostratis et bidentatis, tomentosis, squamam ovatam subacutam subæquantibus.

Common over the United States, and the plant usually designated by this name, with which *C. marginata*, Muhl. and Schk., has been confounded.

C. marginata, named and described by Muhl. in his Gram., and sent by him to Schk., who described and figured it in his Reidg., Part 2, p. 49, fig. 143, is a short plant, 4–8 inches high, (a span high, Muhl.) stocky, with leaves erect and longer than the culm even before the fruit matures; spikes few-fruited and sessile, with fruit distinctly *globose* and short rostrate and sub-stiped; while *C. Pennsylvanica* is about twice as tall, 8–15 inches, slender, with short leaves till late in the season; spikes with more fruit, and the fruit oblong or long-oval, plainly triquetrous.

Both appear easily distinguishable from C. varia, and other species of the same family.

No. 248. *C. Persoonii*, Sieb. Herb., H. Aust., No. 282, secundum Lang in Linnæa, vol. viii, p. 539.
— *vitilis*, Fries, Nov. Mant., iii, p. 137 et Summa Veg. Scand., p. 223.
— *canescens*, L., var. *alpicola*, Wahl.
— *canescens*, L., var. *brunnescens*, Koch.
— - - - var. *sphærostachya*, Tuck. Enum.
— *sphærostachya*, Dew., Sill. Journ., vol. xlix, p. 44, Ser. prima.
— *gracilis?* Schk., Part 1, p. 48.

Spiculis 3–5, ovatis, approximatis in apicem vel infra subremotis, alternis, sessilibus, paucifloris, bracteatis, inferne staminiferis; fructibus *distigmaticis*, ovatis, submarginatis, substriatis, oblongo-lanceolatis vel tereto-rostratis, convexo-planis, glabris cum rostro sæpe dorsum fisso, squama ovata hyalina longioribus; culmis subprostratis, *vitiliusculis;* foliis planis margine scabris.

This more full description of this species than in vol. xlix, p. 44, is here given from a more full examination of the plant with the descriptions of Fries and Lang. The synonyms show the attention to this plant in Europe and in this country. Being unacquainted with the older descriptions of Sieb. and Fries, I had made it a distinct species, as above mentioned.

In his description, Fries states distinctly the difference of C. vitilis and C. Persoonii, and yet in his tabular view, Sum. Veg., p. 72, he denies the true specific difference, and inquires whether they are not the same. But Dr. O. F. Lang, in the Linnæa, edited by D. F. L. von Schlechtendal, Professor and Director of the Botanic Garden at Halle, has proved the identity of these two species. Indeed, the descriptions of Fries and Lang so nearly coincide as to exclude doubt. The chief difference between them is the *split on the back of the beak*, which in the abundant specimens of our country is a character *often*, not always, clearly present.

C. Persoonii, Sieb., is the proper name due to the plant.

This species is wholly different from *C. disperma*, Dew., for which C. vitilis, has been substituted by Dr. Boott. But this has stamens *below*, and C. disperma *above;* and the fruit and scale of the latter are very diverse from those of the former. In our country, *C. Persoonii*, Sieb. the *C. vitilis*, Fries, can not be confounded with *C. disperma*, Dew. The above characters show that this substitution can not be sustained. The somewhat *vine-like* form of C. Persoonii, for which it was called C. vitilis by Fries, is directly opposed to such confounding of names.

It is to be noticed also, that *C. disperma* is not confounded with *C. gracilis*, Ehrh. by Dr. Boott, or with the very different *C. gracilis*, Schk., Part First, p. 48, fig. 24, which is described by Schk. with stamens *below*, and *not above*, and which is probably a minor form of *C. sphærostachya*, the *C. Persoonii*, Sieb. given above ;. see the remarks on that species, vol. xlviii, p. 44, in this Journal.

No. 249. *C. tenax*, Chapman in MS. Boott, Richardsoni Arct. Exped.

C. Chapmani, Sartewellii, Am. Sept. Exsic.

Spica staminifera unica brevi; spicis pistilliferis 2–3, ovatis vel brevi-cylindraceis, densi-fructiferis, inferiore subpedicellata; fructibus *tristigmaticis* variis infra subteretibus, longo-conicis, vel brevioribus et bidentatis, multinervo-striatis tomentosis, squama ovata acuta duplo longioribus.

Culm a foot high, erect, with leaves short and flat; staminate spike short, with oblong and acutish scales; pistillate spikes usually three, lowest pedunculate, ovate or short, cylindric, close-fruited; stigmas three; fruit some tapering downwards, ventricose in middle, long or short conic and often bidentate, villose, many nerved or striate; pistillate scale ovate, acute or mucronate, half the length of the fruit.

Florida; Dr. Chapman, who long since distinguished it from C. dasycarpa Muhl. and gave it the above name.

From C. dasycarpa, whose fruit is ovate, clearly triquetrous, rather obtuse, scarcely nerved or striate, it is easily separated.

Note.—The following views of the synonymy of the species to be mentioned, are presented, in the hope of throwing some light upon a difficulty long felt in our country.

C. loliacea, L. et Wahl.

C. gracilis, Ehrh., Lang in Linnæa, vol. viii, p. 542, No. 56. Sill. Journ., vol. xi, p. 306, Serie prima.

Culmo tenui gracili scabriusculo, foliis planis margine subscabriusculis; spica composita, spiculis 3–4 rotundis paucifloris gynæcandris (infra staminiferis) remotis; fructibus oblongo-ellipticis nervosis obtuse erostratis, ore integerrimo. Lang ut supra.

This description is given from Dr. Lang, a laborious and discriminating Caricographist, because it was made after extensive examinations so late as 1847, and published after his death in the Linnæa by Dr. von Schlechtendal for its singular merits in 1852. On examining recent specimens from Lapland, I find little to change in the description of C. loliacea in vol. xi. The scale of the fruit is not "*acute*" but subacute, and the fruit is *very obtuse*. In the words of Dr. Lang, "Fructus ita obtusi ut apice fere rotundati sunt," evidently following Wahlenberg's description as quoted by Prof. Gray in vol. iv, p. 21, of this Journal, 2nd Series.

The synonymy of *C. gracilis*, Ehrh., has been made difficult by the manner in which the synonyms were left by Schk. in the two Parts on Carices. Prof. Gray gave a plausible solution in the reference just made to vol. iv. To learn if any new light had appeared, I wrote to Dr. von Schlechtendal, Professor in the University of Halle, by which Schkuhr's collection of Carices is possessed, for information. This was immediately given, and the letter shows that *C. gracilis*, Ehrh. is considered to be, and actually is, the true *C. loliacea*, Lin. After stating that Ehrhart published no characters or descriptions of his XII decades of dried specimens, but merely attached to each plant a schedule or label containing the *number*, the *name* and the *author*, and the *locality*, he adds the following:

"In the collection of Carices of Schkuhr himself, which our University possesses, under the name of C. gracilis is present a single specimen of that collection of Ehrhart on whose label is read, '78, *Carex gracilis*, Ehrh., Upsaliæ.'

"Hence there is no doubt, but that Ehrh.'s plant is the same with that of Schk., nor can there be a doubt, that this *C. gracilis*, Ehrh. (of which I possess two original specimens in my own herbarium, marked with the same Ehrhartian label) is clearly the same with *C. loliacea*, Lin, as Schk. has himself already said, and all the more recent botanists agree; and indeed as I maintain from comparison of specimens from Sweden, Norway, and Russia with those of Ehrhart."

As *C. gracilis*, Ehrh. was placed by Schk. with his C. loliacea, it is evident that Schk. considered the plant as the *C. loliacea* L., and of Wahl., for he uses the description of both on *C. loliacea*, L., in his Part Second, No. 47, p. 18; and, having done this, the wonder is, that Schk. should also have quoted *his* C. gracilis, Part First, p. 48 and fig. 24, as a synonym, when the description and figure prove the plant so utterly different from *C. loliacea*, L., in nearly every particular. By the letter of Dr. Schlechtendal, doubt is removed, and the synonymy made certain.

Still further: *C. tenella*, Schk., Part First, p. 23, and fig. 104, is also given by Schk., Part Second, p. 19, as a synonym of *C. loliacea* L. This is another great mistake, but is corrected by the later authors. Thus, *C. tenella*, Schk. is described by Fries in

his Sum. Veg. Scand., p. 224, with a direct reference to the same figure, 104 Schk., and fully distinguished from *C. loliacea*, L. The spikelets of C. tenella have stamens at their summit, while the other has them at the base. By Dr. Lang in the Linnæa, vol. viii, p. 518, C. tenella is described under the name of *C. Blyttii*, Nyland, and the same fig. 104, Schk., quoted. Lang remarks that this species "was formerly, and still is confounded with *C. loliacea*, L.," but is *distinguished "toto cælo" by the position of the stamens from C. loliacea.*

Hence it is evident, that *C. gracilis*, Ehrh., *is not C. tenella*, Schk., Part First, p. 23.

The only remaining difficulty in the synonymy is whether *C. disperma*, Dew. is the same as *C. tenella*, Schk. The separation of *C. gracilis*, Ehrh. from *C. tenella*, Schk., does not of course decide the other case either way. Mr. Tuckerman in his Enum., p. 19, says, "Haud tamen licet, etiam si certum plantam nostram Schkuhrii C. tenellam esse, nomen Deweyi mutare, quia auctor ipse C. tenellæ nomen suum aboluit." But the name, C. tenella, is perpetuated by later writers. Let, then, *C. disperma*, Dew., be absorbed in *C. tenella*, Schk., when their identity is established. This may be accomplished or not ere long by comparison of specimens at home and abroad. In the mean time the following points deserve attention. In Sum. Veg. Scand., Fries states that *C. tenella is taken by many for C. loliacea*, but this mistake can not be made in our country when the specimens are mature, if at all, where C. disperma is compared. Fries indeed says, that *C. loliacea, more slender, more humble*, and *commonly with two fruit, is with difficulty to be distinguished from C. disperma*, Dewey! showing that he had seen C. disperma and judged it to be nearer to C. loliacea than C. tenella is, and of course different from C. tenella. Yet C. disperma differs from C. loliacea "toto cælo" by the position of the stamens, and when the stamens are visible can not be mistaken for *C. loliacea*, L. Neither can their fruit be confounded.

Fries also gives the following characters of C. tenella, viz., "fructibus *ovalibus* obtusis *erostratis* obsolete nervosis, squama *ovato-lanceolata* acuta triplo longioribus," several of which are not found in C. disperma.

From these considerations, the following synonymy are my results:

1. *C. loliacea*, L. et Wahl., Schk., Pars 2, p. 18, excl. synonymis.
   C. gracilis, Ehrh., non C. tenella, Schk.
   C. loliacea, Fries et Lang.

2. *C. tenella*, Schk. Pars 1, p. 23, fig. 104, non Pars 2, p. 18. Fries, Nov. Mart. iii, et Sum. Veg. Scand.
   C. Blythii, Nyland, et Lang in Linnæa.

ART. XXIX.—*On a remarkable change which has taken place in the composition and characters of the Water, supplied to the City of Boston, from Lake Cochituate;* by AUGUSTUS A. HAYES, M.D., Assayer to State of Massachusetts.

(Read at a meeting of the American Academy, 11th January, 1855.)

IN the study of the chemical composition of waters, used for domestic purposes, a wide field is opened for inquiries of high scientific interest, as the accurate comparisons of different waters, lead us through both departments of modern chemistry, the organic and inorganic. This interest is however secondary to the importance of careful inquiries in an economical view, as we have actions of waters on substances with which they come in contact, at one point modifying their composition so as to render them purer or less salubrious, and when a water passes some distance, its characters may thus be made to differ at different points. Not only is the water changed by contact with different bodies, with which it is brought in contact, but conduits of masonry or iron are in special cases rapidly destroyed.

Although my observations on the water supplied to this city were among the earliest made before its introduction, they have been continued since that time, and within two years partial analyses have been made almost weekly, for the purpose of learning the cause of any changes occurring. The results thus obtained will be given in a future paper, with the conclusions arrived at, in a general form—while at present, it is my design to call attention to the condition of the water, as it has existed for about ten weeks.

Cochituate water, derived mostly from surface drainage, as it is found in the Pond or Lake, belongs to the class of peaty waters, so common in New England. It has not characters in common with the green or colorless waters of limestone formations, nor the medium or mixed qualities of our river waters. In its normal state, it may be considered as a pure water, holding in solution four or five grains of mineral salts in one U. S. standard gallon, and these consist of compounds of chlorine with sodium, potassium, calcium, and magnesium, carbonates and silicates of these bases, in varying proportions at different seasons. Its organic constituents, including the gases dissolved, are those of the most importance, as they give it particular characters, modifying its chemical relations and affecting the taste, color, and purity of the fluid.

In the spring and autumnal seasons, there are found ulmic, crenic and apocrenic, and humic acids, with sparingly soluble compounds of these acids and bases, including alumina and oxyd of

iron. With them there is a neutral body, which resembles mucilage from gum, and is usually in a changing state, especially while the water is warm, in the summer season. The gases dissolved are oxygen, nitrogen, and carbonic acid: the nitrogen never has the volume relation to the oxygen which exists in the air, being, except in rare instances, in smaller proportion, and cases have occurred, when the nitrogen was no more than 20 volumes to the oxygen 80. The volume of carbonic acid also varies, while about one volume of all the gases exists in thirty-six of normal water. There are present, also numerous animalcules and infusoria, fresh-water sponges and abundance of ochry matter, resulting from the chemical action of the water on the iron pipes. The animalcules indicate a state, which really exists,—of a disturbed balance between the fish, crustaceans, animalcules, and sub-aqueous vegetation of the lake. Although throughout the year, the water, at times increased by rains and melting snow, cannot be classed with putrid waters, there are periods in every season, during which it closely approaches to these in character.

In the latter part of October last, I was watching, for the increased amount of organic acids, due to the decomposition of vegetable matter, after a season of drought, succeeded by copious rains, when I was greatly surprised to find the humates and apocrenates giving place to crenic acid and crenates, accompanied by a perceptible odor of decomposing vegeto-animal matter, such as is emitted by freshly disturbed soil. This odor, which characterizes the humus from animal matter, continued several days, the water became colorless, while the organic matter, including carbonic acid, increased so as to exceed nineteen times the minimum amount previously found. The condensed vapor from the water had a strong odor of earth, or precisely that of guano from humid climates, and possessed an acrid reaction. No more than a mere trace of ammonia could be thus detected. When the water was mixed with lime and distilled, the condensed vapor was ammoniacal, proving that no carbonate of ammonia from the soil was present, but a *salt* of ammonia due to decomposition. The earthy odor, or (so called) taste, was succeeded by one closely resembling that of fresh-water fish, which, with slight variations in intensity, has continued nearly ten weeks. Before the water throughout the city became thus contaminated, the suggestion arose that the cause was local; the secondary main supplying my dwelling-house having perhaps retained some parts of eels or fish. A careful examination was made and by analysis, a portion of *oil* was separated from the water, which had been filtered through muslin to remove suspended impurities.

By distillation, the odor could be isolated from the water, which thus lost, what was pronounced by good judges, to be the taste of fish oil, while the water, retained the oil, almost destitute of odor.

The general supply of water to a populous city, had thus become very offensive, without any adequate cause appearing, and the evil led to the expression of many hypotheses and suppositions, chiefly without reliable support.

As the subject was one within the reach of experiment, the course adopted was the following: A displacement apparatus of glass, was charged with recently calcined animal charcoal, of medium fineness; over this was placed a conical filter of clean cotton, so that any water, falling on the charcoal, would first pass through the cotton filter. The water from a contracted supply pipe, was allowed to flow slowly on the cotton filter, and passed away, so long as the pores remained open. Removing the cotton filter, the charcoal was allowed to drain, the water displaced by alcohol, and the alcohol by sulphuric ether, without removing the coal. Some oil was found in the alcoholic fluid, while the aqueous ether was colored by it, from a tint of yellow to a light olive color.

By evaporation at 90° to 100°, the ether left some globules of fluid oil, but by far the larger bulk of residue, was a soft solid in granules, without crystalline form. By warming the solid with a little acid, a base was dissolved, generally lime, or lime and ammonia, while the oil floated on the fluid, and was left by evaporation of the water. As thus obtained, this oil was of a light yellow color, presenting both oleic and stearic acids. Its specific gravity was the same as that of lard oil. Alcohol dissolved it without residue. A solution of carbonate of soda saponified it when warmed, proving the acid condition of the oil. With sulphuric acid it blackened, and chlorine changed its color to dark brown.

The oil, as separated from the etherial solution, in different experiments, assumed a solid state at 80° or 90° F. Acids eliminated oily fluids constantly, with the emission of a peculiar odor. Treated with carbonate of soda, when the soap was decomposed, an odor resembling that from adipocere was generally perceptible. When the charcoal, while wet from the water, was distilled, the vapor, which was first condensed, had a strong fish-like odor. It would putrefy and run through the changes resulting from the production of Conferva.

The mass of the water supply, was constantly changing from its state of approach to putrefactive fermentation—in which free crenic acid and crenates appeared, with a large volume of carbonic acid—to its more nearly normal state. At one time, twenty-eight volumes of water evolved, by boiling, one volume of gases. Twenty-five volumes of the gases were diminished only one volume, by phosphorus, warmed and left twenty-four hours; or about four per cent. of oxygen, seventy of carbonic acid, and twenty-six of nitrogen. Such a gaseous atmosphere dissolved in water, could not support animal life, in the higher forms of organization. As the oxygen gas increased in volume, the apocrenates and humates

appeared, and the water which had no action on iron, assumed its ordinary action on this metal. The crustaceans increased in quantity and size, the Cyclops and Daphnia became predominant, and the cotton filters were soon closed by their bodies. Attention was now given to the mass collected on the filter, as had already been done with the sponges, and some vegetable organisms, including Conferva.

The fish-like odor was mostly retained by the filter, which had not been the case in the earlier experiments, and it became easy to separate from the gelatinous mass on the cotton, the oil, with the odor, or apart from it. As separated from the mass, the oil possessed a fugitive green color, at times, but the dried filters extracted by ether, afforded a yellow oil. The variations in color were found to be due to the state of the matter on the filter, which, evidently of animal origin, decayed rapidly, and the oil and odor became merged in a body, much like adipocere. The water, which had been purified by means of animal charcoal, was free from taste and odor; its vapor did not possess odor, and the larger part of the organic matter had disappeared.

As the chief contaminating matter in this water was arrested from a current by even a coarse filter, and the experiments had been repeated so frequently as to leave little else for chemical trials, I placed in the hands of Dr. John Bacon, for microscopical examination, the substance, like that, from which the odorous oil had been taken.

Dr. Bacon at once detected the source of the oil, the bodies of the Cyclops and Daphnia, being in large part filled with it,*—ten or fifteen globules, of different sizes, could be seen in a single subject,—but the most remarkable fact in this connection is the varied color of the oil. Under the microscope while many subjects presented a yellowish-brown oil, some were filled with colorless oil, and not a few had oil of a blackish blue, shading to indigo blue.

This fact explains the production of green and olive green etherial solutions, and it was found that the decomposing remains, were often red and yellowish brown—and in that case afforded light yellow solutions. No other substance, but those named, was found among numerous collections, which could afford oil; the connection between the chemical proofs, and microscopical observations was most skillfully made by Dr. Bacon, in the way of extracting the oil, while the subject was in the field of the instrument.

At this point of the research, a series of experiments was undertaken, which demonstrated that the fluid oil first obtained by animal charcoal, was really due to the presence of broken up and dead crustaceans, which had given free oil to the water.

* The species of Cyclops and Daphnia are usually between $\frac{1}{8}$th and $\frac{1}{16}$th of an inch in length.

Certain modifications of the oil which had been observed, could be traced to the *state* of the mass of crustaceans, before the ether was used as collected at the present time from a portion of water by means of filters of different degrees of fineness, from coarse to very fine, we have the water on one hand free from taste, while the filters retain the matter which rendered the water impure. A portion of this matter placed in pure water gives to it the taste of Cochituate water, while another portion under the microscope presents only living and dead crustaceans.

Dr. Bacon has kindly recorded his observations and allowed me to append his account of them to this paper.

Observations on the Oil contained in the Crustaceans found in the Cochituate Water, by John Bacon, M.D.

The occurrence of numerous transparent globules in the bodies of the minute crustaceans found in the Cochituate water, first attracted my notice in the spring of 1854, and I then ascertained by chemical tests that they consisted of oil. Supposing that they were ova in some stage of development and were probably well known to naturalists, no further observations were made until the bad condition of the Cochituate water attracted public attention; when I called the attention of one of the chemists employed to analyze the water to the presence of this oil and suggested that it might be the cause of the evil. But it did not appear probable to either of us that a small amount of oil could occasion so serious an effect: and thus the matter rested until the commencement of the present year, when Dr. Hayes placed in my hands for microscopical examination the gelatinous substance collected by him on cloth filters. The microscope revealed an abundance of oily globules, in the bodies of the Cyclops and other minute crustaceans, of which the mass on the filter chiefly consisted, and the source of the oil obtained in his experiments was at once evident. At this time, early in January, very few Conferva and other vegetable organisms were found. The empty silicious shells of various Diatomaceæ were abundant as usual, but scarcely any specimens were living, or contained organic matter. Yet the peculiar flavor of the water was as strongly marked, as in the autumn, when Conferva and other vegetable organisms abounded. The crustaceans in which the oil occurs are several species or varieties of Cyclops and Daphnia, and probably other allied genera of the division Entomostraca. In the living animals, the oil is clearly seen by the aid of the microscope, through the carapace which is mostly transparent; and it is distinguished by its high refractive power and other optical characters from the other contents of the shell. It can also be extracted by ether, and still more satisfactorily, by strong alcohol from the body of the animal, while in the field of the microscope. The

quantity present is exceedingly variable, not only at different times, but in different individuals collected at the same time. In a few specimens no globules are visible. In others they are so abundant, that the oil forms at least one quarter part of the bulk of the animal. These large quantities occur only in the Cyclops, which is by far the most abundant form present; the other crustaceans contain much less.

Its distribution in the body of the animal is remarkable, being diffused irregularly in globules of various sizes, (usually spherical and occasionally ovoid or pear-shaped,) and in masses formed by the coalescence of globules; and it appears to have no definite connection with the internal organs of the animal. Sometimes, small globules are seen even in the last joints of the tail. No sac or envelop is visible around them, as they occur in the animal, or when liberated by tearing the body into fragments. Yet globules lying in contact in the body do not unite by moderate pressure, but regain their form when the pressure is removed.

A strong pressure causes them to run together. These facts are compatible with the absence of a proper enveloping membrane. No structure of any kind is visible in the globules. Their color, when isolated, is generally orange, red, or yellow; they range, however, from brownish red to an entirely colorless condition, in different specimens. As the carapace has frequently a tinge of red or green, the color of the oil is of course affected when seen through it.

Finding that the comparatively large size of the crustaceans, allowed of their almost perfect separation from the other bodies suspended in the water, by means of a suitable filter, a quantity was collected from a Cochituate service pipe, and thoroughly washed with distilled water. They were then introduced, mostly in a living state, into distilled water, in an open vessel. In about half an hour, the water began to acquire an odor, and after some hours, both the odor and taste resembled closely the peculiar flavor of the Cochituate. In a day or two, a decided fishy flavor was developed. The water was now somewhat milky, and on microscopic examination, an abundance of colorless oil globules, were seen diffused through it, with some gelatinous matter, derived from the bodies of the dead crustaceans, with the fragments of which, together with exuviæ, the bottom of the vessel was covered. A large proportion were still living and active. In about a week, the water began to regain its clearness, and the odor and taste nearly disappeared. Many of the crustaceans were still alive; and it was noticed that a progressive diminution in the general amount of oil contained in their bodies, was evident in the successive examinations.

In the Cyclops, these globules are found equally in both sexes, and cannot therefore be derived from the ova; in many of the

females, the granular ova masses, in the internal ovaries, are seen in company with the globules—but they are not in connection, nor is there any indication of a transition from one form to the other.

In the Daphnia, the small pellucid globules which constitute the earliest stage of the ova, and also the hibernating eggs, are visible in many specimens, and do not resemble the globules under consideration. The male Daphnia is rarely seen, and I do not know whether the oil is found in both sexes as in the Cyclops.

Since the above observations were made, I have learned, that these oil globules are briefly described by von Siebold. See Dr. Burnett's translation of von Siebold's Anatomy of the Invertebrata, pp. 310 and 334. This author regards them as fat cells, and after stating that they occur in many crustaceans, adds the following remarks: "The fat, which these cells contain plays a part, probably, in digestion and assimilation; for with these animals, the excess of nutriment is deposited as fat to be used in times of need, as for example, during the act of moulting. This explains why the quantity found is so variable, or even may be entirely wanting." I cannot find that they are described by other authors, nor are the appearances, which they present in the crustaceans of the Cochituate, represented in any of the figures I have seen.

ART. XXX.—*On Gum Mezquite;* by CAMPBELL MORFIT, M.D.

GUM Mezquite, known synonymously as *Muckeet*, *Mezqueet* and *Musquit*, and recently presented to public notice by Dr. G. G. Shumard, U. S. A., is said to be the product of a tree flourishing extensively in the high and dry regions of the plains of Western Texas, New Mexico and the adjacent Indian Territory. The facility with which it may be obtained in large quantities, and its very probable prospective value as an article of commerce, give it an interest that led me to a chemical examination, which I have caused to be made in my Laboratory by one of my students, Mr. Frederick W. Alexander.

It is a spontaneous semi-fluid exudation concreting by exposure into tears and lumps of variable size and form. Our sample, which was a part of that brought in by Dr. Shumard, and obtained directly from the U. S. Bureau of Indian Affairs, consisted of small irregular pieces and rounded balls about the size of a hazel nut, semi-transparent, and shading in color from a lemon white to dark amber. When broken, the fracture faces were brilliant; and the gum was easily reduced under the pestle to a dull white powder. One of the balls was enveloped with an outer pellicle of gum about $\frac{1}{16}$th of an inch in thickness.

The specific gravity of the gum was 1·5, but this determination may possibly admit of correction upon purer samples than were disposable for the experiment.

Its proximate composition was found to be,

Water,	11.640
Foreign Matters,	0·236
Bassorin,	0·206
Arabin,	84·967
Ash,	3·000
	100·049

Cerasin was also sought for, but not found. The ash was estimated by burning a given quantity in an atmosphere of oxygen and weighing the residue.

The ultimate analysis, made also by effecting combustion of the carefully dried gum in oxygen gas, yielded, in two separate experiments, the following numbers:

	1.	2.
Carbon,	43·63	43·10
Hydrogen,	6·11	6·50
Oxygen,	47·26	47·40
Ash,	3·00	3·00
	100·00	100·00

These proportions approximate very closely to those obtained from gums Senegal and Arabic by Guerin and Mulder. The general appearance, too, of the gum is similar to that of gum Senegal, and the dark inferior qualities of gum Arabic. In chemical properties, also, it is allied to them ; being insoluble in absolute alcohol, partially soluble in common alcohol, and readily forming with hot or cold water a very adhesive mucilage. It is in fine, a true gum, and promises, in its physical and chemical behavior, much of the advantage, expected by its discoverer, as an economical substitute for gum Arabic or Senegal.

University of Maryland, Baltimore, January, 10, 1855.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the elastic forces of vapors in vacuo and in gases at different temperatures, and on the tension of mixed vapors.*—Under this title Regnault has communicated to the Academy of Sciences the results of an elaborate series of investigations extending from the year 1843 to 1850 and now first made public. The author divides his communication into five parts. The first contains the results obtained on the elastic forces of saturated vapors furnished by a certain number of liquids selected from among those which are easily obtained in a state of purity, in quantity, and at a reasonable price.

The second part treats of the elastic forces of the vapors of saline solutions and of their application to the study of different phenomena of molecular physics and chemistry.

The third treats of the phenomena of the vaporization of liquids in gases.

The fourth of the results of experiments on the elastic forces of vapors furnished in vacuo by volatile liquids displaced or superposed.

The fifth contains the result of experiments undertaken to decide whether the tension of a vapor in vacuo depends or not on the solid or liquid state of the body which furnishes it.

The methods of observation employed to determine the elastic forces of vapors in vacuo are the same as those which the author used in studying the tension of the vapor of water. The author simply gives his results for alcohol, ether, bisulphid of carbon, chloroform and oil of turpentine, for every 10 degrees Centigrade. These are contained in the following table, the tension being expressed in millimeters.

	Alcohol.	Ether.	Bisulph. of carbon.	Chloroform.	Turpentine.
−21°	3·12	——	——	——	——
−20	3·34	69·2	——	——	——
−10	6·50	113·2	79·0	——	——
0	12·73	182·3	127·3	——	2·1
10	24·08	286·5	199·3	130·4	2·3
20	44·00	434·8	298·2	190·2	4·3
30	78·4	637·0	434·6	276·1	7·0
40	134·1	913·6	617·5	364·0	11·2
50	220·3	1268·0	852·7	524·3	17·2
60	350·0	1730·3	1162·6	738·0	26·9
70	539·2	2309·5	1549·0	976·2	41·9
80	812·8	2947·2	2030·5	1367·8	61·2
90	1190·4	3899·0	2623·1	1811·5	91·0
100	1685·0	4920·4	3321·3	2354·6	134·9
110	2351·8	6249·0	4136·3	3020·4	187·3
120	3207·8	——	5121·1	3818·0	257·0
130	4331·2	——	6260·6	4721·0	347·0
140	5637·7	——	——	——	462·3
150	7257·8	——	——	——	604·5
152	7617·3	——	——	——	——
160	——	——	——	——	777·2
170	——	——	——	——	989·0

The author remarks that these results were obtained partly by the direct measure of the tensions in vacuo and partly by the measure of the temperature which the vapor of the liquid presents when boiling under the pressure of an artificial atmosphere. The first method was used for low and the second for high temperatures. In all cases the experiments were made in such a way that the curves of the elastic forces given by the two methods, presented a part in common so as to permit the observer to judge of their coincidence. This coincidence was in the author's former experiments perfect for the vapor of water; he finds it to be perfect also for other volatile liquids provided that these are chemically pure. When however an extremely small quantity of another volatile substance is present, the two methods give different values for the elastic force of the vapor at the same temperature, and this gives an extremely delicate method of judging of the homogeneity of a volatile substance. The author found it easy to obtain perfectly pure

bisulphid of carbon, but difficult to get pure ether and alcohol, while chloroform always contains many substances mixed with it which cannot be separated. Thus the tension of its vapor as directly determined was 342·2 at 36°, while by the method of ebullition it was found to be 313·4 at the same temperature. Some liquids change their molecular structure when long boiled under high pressures, and of this change oil of turpentine furnishes a remarkable example. Other liquids appear to undergo molecular changes when left to themselves for a long time in hermetically sealed tubes: ether is a curious instance of this.

With respect to the second part of the subject, as indicated above, the author in the first place verified the law of Rudberg, that whatever be the boiling point of a saline solution the vapor has simply the temperature which it would have if disengaged from pure water. As however the experiments of Rudberg were made only at ordinary atmospheric pressures, Regnault endeavored to extend our knowledge of the subject by studying the phenomena of the ebullition of saline solutions under very different pressures. The apparatus used was a copper boiler through the cover of which four closed tubes passed, two into the liquid beneath and two into the vapor above. The tubes contained a small quantity of mercury and served to contain the thermometers. A tube communicating with a refrigerator served to condense the vapor while the refrigerator itself communicated with a large reservoir of air, the pressure of which could be varied at pleasure. Concentrated solutions of chlorid of calcium were placed in the boiler and made to boil under various pressures while at the same time the temperatures of the liquid and the vapor were measured. The author gives two tables of his results, of which however our limits permit us to give but one. In this table the first column gives the pressures corresponding to the temperatures observed, the second the temperatures of the liquid, the third the temperature of the vapor and the fourth the temperature which the vapor would have had if it had been produced by distilled water boiling under the same pressure.

1.	2.	3.	4.	1.	2.	3.	4.
mm.	°	°	°	*mm.*	°	°	°
82·52	52·0	47·88	47·84	757·22	——	99·88	99·90
136·61	61·58	58·20	58·16	1807·15	129·86	126·63	126·16
219·44	71·80	68·73	68·61	2182·35	136·30	132·92	132·42
286·43	——	74·94	74·84	2702·13	142·79	140·35	139·81
434·19	87·54	85·09	85·07	3123·69	147·91	145·57	145·00

It will be seen from this table that the thermometer plunged into the vapor constantly indicates a temperature a little higher than that which corresponds to the vapor of pure water under the same pressure. The small difference may be attributed to radiation from the hotter liquid and to small drops of liquid projected by the boiling saline solution. The thermometers plunged into the liquid indicated abrupt variations, sometimes of several degrees. It may then be admitted that the law of Rudberg holds good for pressures much higher and much lower than the ordinary pressure of the atmosphere. By placing the bulb of the thermometer in different parts of the space above the liquid, the author found that, at a distance of 3 or 4 centimeters above the surface of the solution, the thermometer was always wetted and consequently could only indicate the temperature of the vapor of pure water. When the

bulb descends toward the surface the temperature rises but the bulb dries and this drying takes place only in the layers of vapor immediately above the liquid. This appears therefore to give the explanation of the fact observed by Rudberg; the vapor has at first the temperature of the saline solution, as it rises however it parts with its excess of heat in consequence of its low specific heat as compared with its volume, and thus at a certain height above the surface of the liquid has only the temperature which it would have if coming from pure water. As it was found impossible to determine the temperature of the ebullition of saline solutions so as to deduce from these observations certain results, the author directed his attention to the elastic forces of the vapors which these solutions emit in vacuo. These tensions may be determined with great accuracy and their observation has already led to most interesting and valuable results. Thus when any molecular change takes place in the substance dissolved, it is immediately manifested by a singular point in the curve of the elastic forces of the vapor furnished by the solution. Regnault suggests therefore that the study of the tensions of the vapor of saline solutions promises to yield results as important as those which Biot has deduced from the phenomena of circular polarization.

It is generally admitted by physicists that vapors behave in gases as in vacuo, excepting that in gases the equilibrium of tension is established slowly, while in vacuo this takes place instantaneously. The experiments of Regnault on this point confirm those of Magnus and conclusively show that elastic force of a vapor in a gas is less than in vacuo. The apparatus employed was the same as that used by the author in his former researches on the tension of the vapor of water and consisted of a vessel of 600 or 700 C. C. capacity communicating with a mercurial manometer. The whole apparatus was placed in a large vessel filled with water kept at a constant temperature. The vessel was then filled with dry air and the tension of this first determined at different temperatures. A small glass bulb previously filled with the liquid to be examined and introduced into the glass vessel was then broken by heating the vessel sufficiently; the vapor thus produced caused the mercury in the manometer to descend and its elasticity therefore could easily be measured. The following table gives the results of a single series of experiments on the tension of air containing the vapor of ether, the first column giving the temperature, the second the elastic force of the vapor in the air, the third the elastic force of the vapor in vacuo, and the fourth the difference between these two tensions.

			mm.				*mm.*
5·17°	225·94	232·5	6·6	11·09°	297·10	300·2	3·1
14·42	340·15	345·3	5·1	11·11	296·78	300·6	3·8
14·38	336·48	334·5	8·0	19·37	414·02	423·1	9·1
20·78	439·50	445·6	6·1	12·22	311·30	315·0	3·7

Precisely similar results were obtained with a different form of apparatus, with different vapors in air, and with the vapor of ether in different gases. With this second form of apparatus the author also studied the influence exerted on the tension of the vapor by the total pressure of the atmosphere which acts on the liquid and by the quantity of liquid in excess which moistens the sides of the containing ves-

sel. The author's conclusion is that the law of Dalton on mixed gases and vapors may be regarded as a theoretical law which would probably be verified with all rigor in a vessel the walls of which should be formed by the volatile liquid itself of a certain thickness, but this law is inaccurate in our apparatus because the hygroscopic affinity of the matter of the vessel brings the vapor to a tension which is variable and which is always inferior to that which corresponds to saturation. Thus the table which we have given above gives the *maximum* tension of the vapor of ether in air at the temperatures mentioned. The tension of the vapor at the moment that dew begins to deposit on the vessel is far from being equal to that of the vapor in vacuo. If we compress the gaseous atmosphere the condensed liquid becomes more abundant and the tension of the vapor increases and approaches more and more the tension in vacuo. But it only becomes equal to this when a thick layer of liquid is found on the surface of the mercury and when the observation is made immediately after the reduction of volume.

As the result of his experiments on the tension of the vapor of mixed volatile liquids in vacuo, the author finds that two volatile liquids which are not capable of dissolving each other give in vacuo a tension of vapor equal to the sum of the tensions which these substances present separately. It is however only in this case that the law of Dalton is verified. Whenever the liquids mutually dissolve each other, the tension of the vapor is in general less than that which would be produced by the most volatile liquid separately. The difference is greater the less the proportion of the less volatile liquid.

With respect to the last of the subjects of investigation undertaken, the author found that the vapor of liquid acetic acid below the temperature of condensation possesses a higher tension than that of the solid acid at the same temperature. He attributes this however, to the presence of small quantities of foreign substances which in the case of the liquid acid are disseminated throughout the whole mass and therefore exert but a slight influence on the tension of the vapor. In the act of congelation however, the impurity separates from the mass, and therefore must exert a much greater influence on the tension.—*Comptes Rendus*, xxxix, 301, 391, 345, *August*, 1854.

2. *On butylic Alcohol.*—Wurtz has obtained butylic alcohol in considerable quantity by the fractionated distillation of certain varieties of fusel oil. These contained common alcohol, and the corresponding compounds of amyl and butyl, but not that of propyl which Chancel has found in the fusel oil of brandy. Perfectly pure butylic alcohol was obtained by decomposing pure iodid of butyl obtained from the raw alcohol, by means of acetate of silver, and then decomposing the acetate of butyl by caustic potash. It is a colorless liquid more fluid than amylic alcohol, and having a somewhat similar but more vinous odor. It does not deflect the plane of polarization, boils at 109° C. and has a density at 18°·5 of 0·8032. The density of its vapor is 2·589, and corresponds to 4 volumes. It takes fire readily and burns with a luminous flame; it is soluble in 10·5 times its own weight of water at 18°; with potassium and sodium it forms potassic and sodic alcohol; heated with soda lime it gives butyrate of soda. Sulphuric acid forms with it sulpho-butylic acid when the mixture is kept cool, but

at common temperatures decomposes it, forming various hydrocarbons. Chlorid of zinc gives with the alcohol, butene C_8H_8, hydruret of butyl C_8H_{10}, and liquid carburets. By the action of potassium on iodid of butyl the author obtained butyl C_8H_9, (or in Gerhardt's view, $\left.\begin{matrix}C_8H_9\\C_8H_9\end{matrix}\right\}$); it is a colorless oily liquid. The chlorid, iodid and bromid of butyl were found by the usual processes; they are liquid and resemble corresponding compounds of amyl. The iodid of butyl readily reacts with the salts of silver, and in this manner many of the ethers of this radical may be obtained. Wurtz did not succeed in preparing the oxyd of butyl in a perfectly pure state; it appears to be a liquid having an agreeable odor and boiling between 100 and 105°. The carbonate, acetate, nitrate and formate of butyl are all liquid and do not require special notice in this place. By distilling sulpho-butylate of potash with cyanate of potash, dissolving the distillate in alcohol and then distilling this mixture with caustic potash, the author obtained butylamin. In a pure state this ammonia $N\left\{\begin{matrix}C_8H_9\\H\\H\end{matrix}\right.$ is liquid and boils at 69°–70°; it is soluble in water, alcohol and ether, and the aqueous solution is extremely caustic and precipitates most metallic solutions like ammonia itself; it dissolves alumina and even gelatinous silica. The platinum salt of this base is $C_8H_{12}NCl+PlCl_2$; the gold salt is $2C_8H_{12}NCl+AuCl_3$. The author points out the fact that butylamin has the same boiling point with petinin, with which it is possibly identical.—*Ann. de Chemie et de Physique*, xlii, 129.

3. *On the volumetric determination of Copper.*—De Haen has succeeded in applying the general method of Bunsen to the determination of copper by means of the well known reaction $2CuO, SO_3+2KI = Cu_2I+2KO, SO_3+I$. The details of the process are as follows: The copper is to be brought into the form of sulphate, the solution being either neutral or containing only a moderate quantity of free sulphuric acid. The solution is then to be diluted in a measuring flask to a definite volume, so that 100 C. C. contain 1–2 gr. of oxyd of copper; 10–20 C. C. of Bunsen's solution of KI are to be introduced into a large beaker glass; 10 C. C. of the solution of copper are to be added and the whole mixed; the solution of sulphurous acid is then to be added, and the operation finished by Bunsen's process. The presence of free nitric, chlorhydric and acetic acids, as well as of oxyd of iron and all other substances which decompose iodid of potassium must be avoided. The sulphurous acid must also be added without loss of time and the solutions must not be too dilute. If these conditions be observed a very accurate result is obtained.—*Ann. der Chemie und Pharmacie*, xci, 237. [It will be observed that this method fails entirely precisely in the case in which it is most desirable to have a very accurate and expeditious process for determining copper, namely, in the assay of copper ores. —W. G.]

4. *On the action of iodid of amyl upon an alloy of sodium and tin.*—Grimm has studied and described an extensive series of new radicals containing tin and the elements of amyl, and obtained by the action of iodid of amyl upon an alloy of tin and sodium. As however, these

radicals do not differ essentially in properties from those already described by Löwig and other chemists, we shall content ourselves with giving their formulas and names, Am being employed as a symbol for amyl.

Methstannbiamyl, - - - -	Sn_2Am_4
Methstannamyl, - - - - -	Sn_2Am_3
Methylenstannamyl, - - - -	$SnAm_2$
Stannamyl, - - - - - -	SnAm
Bistannamyl, - - - - -	Sn_2Am

It will be observed that these compounds correspond to those of ethyl and tin, but that while the amyl compound corresponding to ethstannethyl Sn_4Am_5 is wanting a radical is here met with to which the ethyl series affords no parallel, namely, Sn_2Am_4.—*Journal für practische Chemie*, 62, 34.

5. *New organic radicals containing arsenic.*—Cahours and Bre-lie have still further extended our knowledge of this very interesting class of bodies. By the action of iodid of methyl upon arseniuret of sodium two radicals are obtained, one corresponding to stibmethyl, the other the iodid of an arsenic ammonium which the authors term arsenmethylium. This iodid is represented by $(C_2H_3)_4As.I$, and crystallizes in magnificent brilliant tables. By double decomposition with the salts of silver other salts may be readily obtained. The same radical is also obtained when iodid of methyl is brought into contact with cacodyl, the action being represented by the equation $2C_2H_3I+2C_4H_6As=(C_2H_3)_4As.I+C_4H_6AsI$. With the iodids of ethyl and amyl similar results are obtained, and the iodids of two new arsenic ammoniums are formed having the formulas $(C_2H_3)_2(C_4H_5)_2As.I$ and $(C_2H_3)_2(C_{10}H_{11})_2As.I$. These results in connection with those of Landolt already mentioned in this Journal, leave no doubt as to the constitution of cacodyl which must be regarded as Dimethyl-arsenic.—*Comptes Rendus*, xxxix, 541.

[*Note.*—In connection with this subject the writer desires to draw the attention of chemists and of medical men to the probable advantages of employing the nitrogen, antimony and arsenic *ammoniums* in place of quinine as antiperiodic therapeutic agents. It will be remembered that the compound ammoniums of Hoffmann, tetramethyl-ammonium $N(C_2H_3)_4$ for instance, possess in their saline compounds an intensely bitter taste. Now as quinine in combination is also an ammonium, NR_4, it appears probable that the bitter taste is in some measure at least, characteristic of the type $R'R_4$ of the ammoniums. This appears to be the case with the antimony and arsenic ammoniums so far studied, and I therefore suggest that careful experiments should be made to determine whether these compound ammoniums which can readily be prepared in the laboratory and at moderate prices may not answer in intermittent fevers, &c. as well as the expensive salts of quinine.—W. G.]

6. *Action of iodid of phosphorus upon glycerine.*—Berthelot and de Luca have observed that when crystallized iodid of phosphorus PI_2 is distilled with glycerine propylene gas is evolved, while water and iodated propylene C_6H_5I distill over. The proportions of these products

vary with those of the materials employed. Iodated propylene is a colorless liquid boiling at 101° C. It is rapidly colored by the action of air and light, and then emits very irritating vapors: its density is 1·789 at 16° C. A solution of ammonia after forty hours action at 100° completely decomposes iodated propylene; the product is a volatile alkali, which according to the authors, has the formula C_6H_9N and appears to be propylamin $C_6H_7 . NH_2$ (?). Heated with mercury and chlorhydric acid the iodated propylene is decomposed, yielding propylene; the reaction is represented by the equation $C_6H_5I + HCl + 4Hg = C_6H_6 + Hg_2Cl + Hg_2I$. The authors recommend this process for the preparation of propylene. Propylene unites directly with iodine when the mixture is exposed to the sun's light, and yields a heavy colorless liquid having the formula $C_6H_6I_2$; the authors term it iodid of propylene.—*Comptes Rendus*, xxxix, 745. W. G.

II. Geology, Botany, Zoology.

1. *Darstellung der Flora des Hainichen-Ebersdorfer und des Flöhær Kohlenbassins;* by H. B. Geinitz. 80 pp. large 8vo, with 14 copper plates in large folio. *Leipzig*, 1854. Gekrönt und herausgegeben von der fürstlich Jablonowskischen Gesellschaft zu Leipzig.—Dr. Geinitz, the accomplished geologist and Palæontologist of Leipzig, has made in this new work of his, a most valuable contribution to the science of the Coal Formation, and particularly that of Saxony. The work contains an account of the older coal measures in the neighborhood of Hainich and Ebersdorf in Saxony, which is synchronous with the carboniferous limestone, and also descriptions of the true coal formations from the neighborhood of Flöha near Chemnitz and Zwickau. The Hainichen-Ebersdorf beds present two members, a conglomerate below, and a coal-bearing sandstone above associated with clay shale, the former in some places at least 2000 feet thick, the latter about 1700 feet. The Flöha basin, contains, commencing below, 1, a lower sandstone with some some thin coal seams; 2, a gneissoid conglomerate, metamorphic; 3, a Felsite porphyry, an eruptive rock; 4, an upper sandstone with clay slate and thin coal seams; 5, claystone. The older coal rocks afford—an Annelid-like species, named *Gordius carbonarius* G. near the *Nemapodia tenuissima* of Emmons (Tacon. Syst., pl. 2, fig. 1); also the coal plants *Calamites transitionis* Göp., *C. Römeri* Göp., *Sphenophyllum furcatum* Lind.—*Sphenopteris distans* Sternb., *Hymenophyllites quercifolius* Göp., *Cyclopteris tenuifolia* Göp., *Cyatheites asper* Brongn., *Lycopodites dilatatus* L. and H., *Lepidodendron tetragonum* Sternb., *Sagenaria Veltheimiana* Sternb., *S. caudata* Presl., *S. polyphylla* Römer, *Halonia tuberculosa* Brongn., *Knorria imbricata* Sternb., *Stigmaria inæqualis* Göp. The Sagenariæ are the common species. The Stigmariæ appear according to Geinitz, to be in the Hainich region the roots of the Sagenariæ, and he quotes Richard Brown respecting the Stigmariæ pertaining sometimes to Lepidodendra as well as Sigillariæ. On one plate is represented a leaf supposed to belong to a true Sigillaria. The plates illustrating this memoir are exceedingly beautiful, and of very large size.

Dr. Geinitz is engaged on a still larger work on the Flöha coal formation to contain 35 plates.

2. *A Monograph of the Cirripedia with figures of all the species; the Balanidæ or sessile Cirripedes, the Verrucidæ, etc.;* by CHARLES DARWIN, F.R.S., F.G.S. 684 pp., 8vo, with 30 copper plates. 1854. *London.* Ray Society.—The volume by Mr. Darwin on the Lepadidæ or pedunculated Cirripedes, published in 1851, was noticed in a former volume of this Journal, and also his memoir on the Fossil Lepadidæ, published by the Palæontographical Society. We welcome with peculiar pleasure its successor which completes the subject. Mr. Darwin's works are the result of great labor and extreme care, and have a critical accuracy which entitles them to the highest confidence. In the work just issued, the anatomical structure of species of the different groups is thoroughly made out and much that is new presented. The nervous system is brought out complete, even to the nerves passing to the eyes. The remarkable peculiarities of the genera Cryptophialus and Alcippe, pedunculate Cirripeds, are well detailed. Mr. Darwin shows that the sexes are distinct as in Ibla and Scalpellum; while all the Balanidæ are hermaphrodites. We might cite largely from the work to the advantage of our readers, but refer them to the volume, which has the high value of giving figures of all the species, as well as good descriptive details.

III. ASTRONOMY.

1. *Elements of Euphrosyne* (31), (Astron. Jour., 79.)—The asteroid discovered on the first of Sept. last by Mr. James Ferguson, has received the name EUPHROSYNE. The following elements of its orbit have been computed by the discoverer from Washington observations of Sept. 2, 6, 10, 29 and 30: Oct. 5, 7, 30 and 31: Nov. 2, 4 and 5; giving the three following normal places referred to the mean equinox of 1856·0.

M. T. Berlin.	R. A.	Dec.
Sept. 5·0	$1^h\ 51^m\ 21^s{\cdot}79$	$-2°\ 54'\ 48''{\cdot}11$
Oct. 5·0	1 28 11 ·00	2 26 54 ·78
Nov. 4·0	0 56 39 ·88	-0 57 56 ·13

Epoch 1854 Sept. 14·0 M. T. Berlin.

Mean anomaly, - -	300° 57′ 52″·62	
Long. perihelion, - -	94 0 37 ·73	Mn. Eqnx.
" asc. node, -	31 24 24 ·21	1856·0
Inclination, - - -	26 28 21 ·3	
Angle of excentricity, -	12 31 23 ·7	
Log. mean daily motion,	2·8008456	
" semi-axis major	0·4994407	

IV. MISCELLANEOUS INTELLIGENCE.

1. *On an Atmospheric Electrical Phenomenon;* by H. WARE, (from a letter to Prof. Silliman, dated Cambridge, Mass., Jan. 25, 1855.)—My friend, Mr. J. M. Batchelder wrote me a few days since that you would like some fuller account of a remarkable electrical phenomenon seen by me, than he was able to give, and it gives me pleasure to comply with his request, though regretting that the matter had not come under the notice of some more competent observer.

On Sunday evening, Dec. 17, 1854, while walking over the West Boston bridge (the long bridge across the Charles River, between Bos-

ton and Cambridge), my attention was attracted, when about half way across (the bridge is 2483 feet long), by a loud hissing noise proceeding from the iron lamp-posts, which, for a moment, I supposed to be caused by steam from the snow melting on the lanterns, but, after examining several, found this to be a mistake. After some time I felt a succession of sharp pricks on my forehead, and raising my hand to remove my hat, was surprised by seeing a brilliant discharge of electric sparks wherever my fingers touched or approached the rim of my hat (which was of felt). This gave me a new hint, and, coming soon after to a part of the bridge where the lamps were extinguished I saw from the ventilator on the top, and from every angle and point of the lantern, long streams of electric light, streaming out for some 6 or 8 inches, (somewhat in the fashion depicted in the figure.)

Holding up my cane, the same appearance was observed, the light streaming in every direction from the steel ferule (which was quite large) for 3 or 4 inches; and the same phenomena were noticed appearing from the tips of my fingers which were covered by *woollen* gloves. The sound was quite loud, not only from the lamp-posts, but also from my hat, cane and fingers; that from the *lanterns* being heard very loud quite across the bridge, which is 40 feet wide, and from a number of lamps at the same time, they being perhaps 200 feet apart; the sound resembled that of blowing off steam, as it seemed, at first; but was more like the drawing off of a *continuous* stream from an electrical machine to a jar, only of course vastly louder than I ever heard in that way. I observed that these displays were to be seen only at a height of some 5 feet from the pavement of the bridge (which at high tide is some 6 feet above the water), and I think, though am not confident, *only* on that part of the structure which is filled in *solid*, being some 600 feet on the Cambridge end, the rest of it being built on *piles*. The phenomenon diminished in intensity as I approached the Cambridge end and ceased entirely on gaining terra firma. This was between 11 and 12 o'clock at night, snowing fast and the wind strong from the northeast; high tide at 9.10 P. M. Had Cambridge not been so far off and the hour so late I should have roused some of my friends, the philosophers, from their slumbers that they might have taken more intelligent observations than my ignorance was equal to. I spent more than half an hour in the storm, amusing myself with such tests as occurred to me, and hoping that some other person would come along whose attention I could direct to the phenomenon, but failed even to meet a watchman.

2. *On the Clearness of the Atmosphere in Oroomiah;* by Rev. D. T. STODDARD, (from a letter addressed to Sir John F. W. Herschel, dated Oroomiah, Persia, N. Lat. 37° 28′ 18″, Long. E. from Greenwich 45° 1′, November 23d, 1852, and published in the Proc. of the Amer. Oriental Society, 1853, p. 3.)—Presuming that a letter written to you from ancient Media, and relating to your favorite science, will not be unacceptable, I shall make no apology for the liberty I take in addressing you. My home is in Northern Persia, where I have resided for the last nine years, as an American Missionary to the Nestorian Christians. To give

you an idea of our geographical position, I have noted, above, our latitude and approximate longitude. As I wish also to give you a glance at the physical features of this region, let me invite you to come with me upon the flat, terraced roof of my house, where I am sure you will be delighted with the scene before you. Standing at an elevation of more than a mile above the ocean, and a thousand feet avove the adjoining country, you may look down upon one of the loveliest and most fertile plains in all the East. Extending for forty miles in length, and from twelve to fifteen in breadth, the district of Oroomiah smiles with hundreds of villages, is verdant with thousands of orchards, and rows of poplars, willows and sycamores by the water-courses, and in the early summer waves with innumerable fields of golden grain. Here the peach, the nectarine, the apricot, the quince, the cherry, the pear, the apple, and the vine, flourish in luxuriance, and give the appearance of a variegated forest. Beyond the plain, you see the lake of Oroomiah, reflecting the purest azure, and studded over with numerous islands, while further on rise distant and lofty mountains, their outlines projected on the cloudless Italian sky, and forming a beautiful contrast with the plain before you. The city of Oroomiah, about six miles distant, which is so embosomed in trees as almost to be hidden from view, is the probable birth-place of Zoroaster; and the mounds which are so conspicuous in different parts of the plain, and which are formed entirely of ashes with a scanty soil upon them, are supposed to be the places where the sacred fire was ever kept burning, and the Persian priests bowed in adoration to the rising sun.

The temperature of this elevated region is very uniform, and the greater part of the year very delightful. During the months of June, July, August, September, and sometimes October, there is little rain, and the sky is rarely overcast. Indeed, I may say that often for weeks together not a cloud is to be seen. As a specimen of the climate in summer, I send accompanying this my meteorological register for the month of August last. The observations were taken at our house on Mt. Seir, but do not differ essentially from those taken on the plain at the same season, except that the thermometer is here a few degrees lower, and the air somewhat drier, especially at night.

No one has ever travelled in this country, without being surprised at the distinctness with which distant objects are seen. Mountains fifty, sixty, and even a hundred miles off, are projected with great sharpness of outline on the blue sky; and the snowy peak of Ararat, the venerable father of mountains, is just as bright and beautiful when two hundred miles distant, as when we stand near its base. This wonderful transparency of the atmosphere frequently deceives the inexperienced traveller; and the clump of trees indicating a village, which seems to rise only two or three miles before him, he will be often as many hours in reaching.

In this connection, you will be interested to know that the apparent convergence of the sun's rays, at a point diametrically opposite its disc, which, if I mistake not, Sir D. Brewster speaks of as a very rare phenomenon, is here so common that not a week passes in summer when the whole sky at sunset is not striped with ribbons, very much like the meridians on an artificial globe.

But it is after nightfall that our sky appears in its highest brilliancy and beauty. Though accustomed to watch the heavens in different parts of the world, I have never seen anything like the splendor of a Persian summer evening. It is not too much to say that, were it not for the interference of the moon, we should have seventy-five nights in the three summer months, superior for purposes of observation to the very finest nights which favor the astronomer in the New World. When I first came here, I brought with me a six-feet Newtonian telescope, of five inches aperture, of my own manufacture; and though the mirrors have since been much tarnished, and the instrument otherwise injured, its performance is incomparably superior to what it was in America. Venus sometimes shines with a light so dazzling that at a distance of *thirteen feet* from the window I have distinguished the hands of a watch, and even the letters of a book.

Some few months since, having met with the statement that the satellites of Jupiter had been seen without a glass, by a traveller on Mt. Etna, it occurred to me that I was in the most favorable circumstances possible for testing the power of the unassisted eye, and I determined at once to make some experiments on the subject. My attention was, of course, first turned to Jupiter, but, for a considerable time, with no success. It was always so bright, and shot out so many rays, that it seemed quite impossible to detect any of its moons, even at their greatest elongation from the planet. I varied the experiment in several ways, by looking through the tube of a small telescope, from which the lenses had been taken, and also by placing my eye near the corner of a building, so as to cut off the most brilliant rays of the planet, and yet leave the view unobstructed to the right hand or the left; but in neither case could I find any satellite. Some time after, I was sitting on the terrace as daylight was fading into darkness, and thought I would watch Jupiter from its first distinct appearance, till it shone out in its full splendor. This time I was exceedingly gratified, just as stars of the first and second magnitude were beginning to appear, to see two extremely faint points of light near the planet, which I felt sure were satellites. On pointing my telescope towards them, my first impressions were confirmed, and I almost leaped for joy at my success. Since that night, I have many times, at the same hour of the evening, had a similar view of these telescopic objects, and think I cannot be mistaken as to the fact of their visibility. I must, however, add that none of my associates, who at my request have attended to the subject, are *sure* that they detect them, though the most sharp-sighted individual feels some confidence that he can do so. As these friends, however, are not practical observers, their failure to see the satellites does not shake at all my belief that I have seen them myself.

The time during which these satellites are visible is hardly more than ten minutes. The planet itself soon becomes so bright that they are lost in its rays. I will not stop to discuss the question, in itself a most interesting one, why they are visble at all, when stars of the third and fourth magnitudes are not distinguishable, but merely give you the facts in the case, knowing that you will reason on them much better than I can. Both the fixed stars and the planets shine here with a beautifully steady light, and there is very little twinkling when they are forty degrees above the horizon.

Having come to a satisfactory conclusion about the satellites of Jupiter, I turned next to Saturn. This planet rose so late in the night that I had not seen it while watching Jupiter, and I was curious to know whether any traces of a ring could be detected by the naked eye. To my surprise and delight, the moment I fixed my eye steadily upon it, the elongation was very apparent, not like the satellites of Jupiter, at first suspected, guessed at, and then clearly discernible, but such a view as was most convincing, and made me wonder that I had never made the discovery before. I can only account for it from the fact that, though I have looked at the planet here with the telescope many times, I have never scrutinized it carefully with the naked eye. Several of my associates, whose attention I have since called to the planet, at once told me in which direction the longer axis of the ring lay, and that too without any previous knowledge of its position, or acquaintance with each other's opinion. This is very satisfactory to me, as independent collateral testimony.

I have somewhere seen it stated, that in ancient works on astronomy, written long before the discovery of the telescope, Saturn is represented as of an oblong shape, and that it has puzzled astronomers much to account for it. Am I not correct in this impression? and, if so, is it not possible that here, on these elevated and ancient plains, where shepherds thousands of years ago watched their flocks by night, and studied the wonders of the glorious canopy over their heads, I have found a solution of the question?

After examining Saturn, I turned to Venus. The most I could determine with my naked eye was, that it shot out rays unequally, and appeared not to be round; but, on taking a dark glass, of just the right opacity, I saw the planet as a very minute, but beautifully defined, crescent. To guard against deception, I turned the glass in different ways, and used different glasses, and always with the same pleasing result. It may be that Venus can be seen thus in England, and elsewhere, but I have never heard of the experiment being tried.

Let me say here, that I find the naked eye superior for these purposes to a telescope formed of spectacle glasses, of six or eight magnifying power. This is not, perhaps, very wonderful, considering that in direct vision both eyes are used, without the straining of any one of the muscles around them, and without spherical or chromatic aberration, or the interposition of a dense medium.

As I am an entire stranger, and at the same time am desirous of having these statements make their full impression on your mind, it is proper for me to say that I was formerly for several years a pupil of Professor Olmsted of Yale College, New Haven, and have since been admitted to his special friendship; and that I was associated for some time in observations with young Mason, whose early death you have spoken of as a loss to the astronomical world. And though, no doubt, very many persons have more accurate habits of observation than myself, a practice of fifteen years has done much to train my eye for researches like these.

You will also bear in mind the great dryness of our atmosphere, indicated by the register, as well as our great elevation. Capt. Jacob, (Proceedings of the Edinb. Royal Society, vol. ii, No. 36,) in speaking of the extinction of light in the atmosphere, says: "The loss of light in passing from the zenith through a homogeneous atmosphere of

5·2 miles will be ·303. I was much astonished at first discovering that the air had so great absorbent powers, and many ideas are suggested by the fact."

My letter is already becoming tedious, but I will venture to trespass on your patience further, by naming a few test-objects, which will enable you the better to compare the advantages of our position with your own.

1. δ Cephei. This I have looked at repeatedly with my naked eye, and though I cannot be *sure* that I have seen it double, I put it down, in astronomical langunge, as "strongly suspected."

2. The two small stars in the neighborhood of the pole-star, and in the general direction, of γ Cephei (thus $\cdot\,\cdot\,\cdot$) are seen distinctly, and almost every night, as a single point of light.

3. 4 and 5 ϵ Lyræ are very beautiful and well defined. When lying on my back, the view of these stars, as they have passed near the zenith, has been very similar to that I have often had of Castor in a good telescope. There being *no dew* here, it is almost the universal custom for the people to sleep upon the terraced roofs, which gives them an opportunity, if so disposed, to gaze upon the blue vault above them.

4. α Libræ is seen as two stars in any ordinary state of the atmosphere, as readily as α Capricorni would be in America.

5. Mizar and Alcor in Ursa Major. On looking at these any favorable night, two faint stars, which must be telescopic in England, are distinctly seen. They appear somthing like this $\left(\begin{array}{c} \cdot\,{}^{\cdot 80} \\ \zeta\cdot\quad\cdot \end{array}\right)$.

As I am absorbed in other and pressing labors, which allow me to devote only an occasional thought to astronomical pursuits, and as, besides, I am not furnished with any first rate instruments, allow me to suggest the great desirableness of some experienced observer's coming here to avail himself of this magnificent climate. One who should spend even a limited period in Oroomiah, might safely promise himself a good, and perhaps a very rich, harvest of astronomical discovery.

The averages of the meteorological register for August, alluded to above, were as follows:

Barometer reduced.

Sunrise.	2 P. M.	10 P. M.
24·246	24·247	24·235

General average, 24·242
Barometer highest, 24·417
" lowest, ·097
Difference, ·320

Fahrenheit's Thermometer.

Sunrise.	2 P. M.	10 P. M.
67°·4	79°·45	71°·37

General average of the three observations, 72°·74.

Hygrometer—wet bulb.

Sunrise.	2 P. M.	10 P. M.
54°·82	60°·43	55°·37

General average from the above, 56°·87

Average difference of Hygrometer and Thermometer, 15°·87.
" " " " " " at 2 P. M., 19°·02.

Greatest change of Thermometer in 24 hours, 18°.

N. B. The daily observations differ but little from the weekly average. One day follows another with great uniformity.

3. *Abstract of Meteorological Observations made at Burlington, Vt., in* 1854; by Z. THOMPSON.—The location where the observations were made, is one mile east from Lake Champlain and 256 feet above it (346 above the sea) in Lat. 44° 29′, and Long. 73° 11′.

1854.	THERMOMETER.				BAROMETER.			
Months.	Mean.	Highest.	Lowest.	Range.	Mean.	Highest.	Lowest.	Range.
	°	°	°	°	Inches.	Inches.	Inches.	Inches.
January, . .	19·57	53	−17	70	29·74	30·41	28·85	1·56
February, .	16·31	46	−12	58	29·80	30·41	29·18	1·23
March, . .	30·18	56	6	50	29·61	30·08	28·84	1·24
April, . . .	39·21	69	17	52	29·73	30·27	29·22	1·05
May, . . .	57·67	83	27	56	29·66	30·01	29·30	·71
June, . . .	64·03	86	40	46	29·64	29·93	29·35	·58
July, . . .	73·95	99⅓	52	47⅓	29·75	29·98	29·51	·47
August, . .	68·85	91	49	42	29·72	30·00	29·41	·59
September, .	60·10	95	34	61	29·77	30·18	29·20	·98
October, . .	51·10	76	30	46	29·77	30·17	29·08	1·09
November, .	37·63	63	13	50	29·53	30·21	28·80	1·41
December, .	17·76	42	−21	63	29·64	30·46	28·84	1·62
Annual result,	44·71	99⅓	−21	120⅓	29·70	30·46	28·80	1·66

1854.	WINDS.								WEATHER.		SNOW.	WATER.
Months.	N.	N.E.	E.	S. E.	S.	S. W.	W.	N. W	Fair.	Cloudy.	Inches.	Inches.
January, .	10	1	0	2	11	1	4	2	20	11	14	1·82
February, .	9	2	1	2	7	0	4	3	17	11	17	1·65
March, . .	8	0	1	2	11	1	4	4	19	12	7	1·69
April, . .	15	0	1	1	9	1	1	2	19	11	12	3·60
May, . .	9	1	1	2	12	1	1	4	26	5	0	1·62
June, . .	15	1	0	0	12	1	1	0	23	7	0	2·88
July, . .	8	0	1	1	16	1	2	2	30	1	0	1·60
August, .	9	2	1	2	11	1	4	1	29	2	0	0·61
September,	10	2	0	1	15	0	0	2	26	4	0	4·44
October, .	6	1	1	1	18	0	1	3	23	8	1	2·26
November,	6	0	0	3	11	1	4	5	15	15	6	2·17
December,	6	2	1	1	12	2	3	4	18	13	21	1·11
	111	12	8	18	145	10	29	32	265	100	78	25·45

The results in the preceding tables were derived from three daily observations, made at sunrise, 1 P. M., and 9 P. M.* The warmest day in the year was the 4th of July, the mean temperature of which was 85°, and the coldest was the 22d day of December the mean of which was −14⅔°. The greatest cold in the year, was −21°, at 6 o'clock in the morning of the 20th of December. The mean temperature of the year was 0°·15 colder than the average of the preceding sixteen years, and 0·51 colder than 1853. The range of the thermometer was 14⅔° greater, and that of the barometer 0·30 inches less than in 1853.

The fall of water in rain and snow was 7·59 inches less than in 1853, and 6·96 inches less than the average fall in the preceding sixteen years; and it was 0·89 inches less than in any one of those years, 26·35 inches in 1849 being the least.

* I continue my observations at these hours for the easy comparison of the results, with the results of my former observations, extending back twenty years and made at the same hours. I also note in my journal the temperature at 7 A. M., and 2 and 9 P. M., which are the times adopted in the Smithsonian system of Meteorological Observations. The annual mean temperature deduced from these last observations, average about *three-fourths of one degree* higher than that derived from the former.

During the summer of 1854, this section of country is believed to have suffered more from drought than in any former season since its settlement, and the fall of water in the three summer months was never before known to be so small. The following table exhibits the amount of water which fell in those months in seventeen consecutive years.

Year.	June.	July.	Aug.	Total.
	Inches.	Inches.	Inches.	Inches.
1838	5·37	3·25	2·41	11·03
1839	2·70	6·26	1·91	11·87
1840	2·84	4·18	3·51	10·53
1841	5·16	2·87	1·40	9·43
1842	3·24	4·62	1·74	9·60
1843	4·58	2·59	2·09	9·26
1844	2·08	5·15	3·46	11·39
1845	2·08	4·51	2·37	8·96
1846	3·63	5·08	0·48	9·19
1847	5·05	4·05	3·12	12·22
1848	2·19	3·57	4·40	10·16
1849	1·41	1·73	5·69	8·83
1850	3·18	5·08	0·89	9·15
1851	7·83	3·81	1·92	13·56
1852	4·76	4·99	1·50	11·25
1853	1·74	3·12	3·46	8·32
1854	2·88	1·60	0·61	05·9

By this table it will be seen that the amount of rain in the three summer months of 1854, was 3·23 inches less than in the same months in any one of the preceding sixteen years, and less than one-half the average for those months for the same period. During the continuance of the drought, fires prevailed extensively, destroying large quantities of lumber, growing timber, fences and buildings, and the atmosphere was, most of the time, densely filled with smoke. In consequence of the drought, the summer crops were greatly injured and that of potatoes nearly ruined.

The fall of snow in 1854, was seventy-eight inches, which was twelve inches less than in 1853 and twenty-five inches less than in 1852. Sleighs run, more or less, for three or four weeks, but the sleighing could hardly be said to be good at any time. The lake became entirely frozen over the 4th of February, was passable by teams the 6th in all directions. The passing became unsafe the middle of March —the ice was broken up the 10th of April, and the lake became clear and the steamers were out the 18th. The lake was highest May 10th, being then one foot four inches below extreme high-water mark, and was lowest September 1st, being seven feet five inches below high water, showing a change of level amounting to six feet one inch.

Robins and Bluebirds were seen March 12th, Song Sparrows the 15th. Red Plum in blossom May 16th, Cherry 18th, Pear 20th, Crab Apples 23d, Common Apple 25th.

The Aurora Borealis has occured less frequently than in some previous years. I find the following notes in my journal, but as my location is not favorably situated for observing the meteor near the northern horizon it may have occurred sometimes without being noticed.

January 23d, A beautiful low auroral arch in the N. E. from 8 to 10 P. M.; 28th, several ill defined arches in the N. about 8 P. M.; 29th, slight Aurora Borealis.

February 17th, Slight Aurora Borealis; 24th, a very bright aurora seen through various openings in the clouds; 27th, Auroral arch in the N., 10° high and well defined at 9 P. M.

March 16th, Auroral glow in the N. E.; 21st, Auroral arch about 8° high at 10 P. M.; 30th, a low arch of light in the N. E. at 9½ P. M.

April 15th, Auroral arch in the N. about 30° high at 9 P. M.; 19th, streamers in the N. reaching as high as the pole star, at 9 P. M.; 20th, a bright glow in the N. with streamers reaching up half way to the pole. 21st, A very fine exhibition of the aurora; at 9 P. M. a narrow

belt extended from E. 8° S., overhead to N. 25° W. bending a litle south in the eastern part, with an average width of about $2\frac{1}{2}$° and well defined. 23d, Another splendid aurora; at $8\frac{1}{2}$ P. M. an arch extended from E. to N. W. bending S. through the zenith; at 9 the vertex of the arch had moved S. about 20°, while the ends of the arch had apparently remained stationary. There were in the mean time other bright arches in the N.; in these the flitting motions of the light were very conspicuous.

May 15th, An ill defined auroral arch in the N., 18° high—sky beneath it, nearly black; 19th, slight aurora.

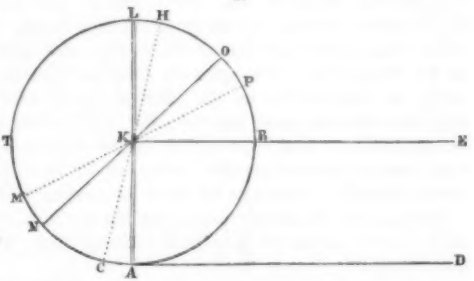
July 19th, Slight aurora in the N. W.; 27th, a low auroral arch in the N.

September 13th, Auroral arch quite low; 21st, slight auroral light; 26th, slight auroral light and several shooting stars.

By the foregoing notes, it will be seen that the aurora borealis was of very rare occurrence during the last half of the year, it having been observed only five times after the 19th of May, and not once in the last three months. During the entire year it was observed only twenty-one times. In former years its occurrence has been annually between thirty and forty times.

4. *Demonstration of the Theory of the Pendulum Experiment;* by Rev. J. L. Dagg.*—Let TABL, fig. 1, be a circular table, over the centre of which K, let a pendulum be suspended. If this pendulum be made to vibrate over any diameter of the table, it will continue to vibrate over the same as long as it continues to move; provided the table remains at rest, and the motion be undisturbed by any interfering cause.

1.



If all the parts of the table move, with equal velocity, in the same direction; if the point from which the pendulum is suspended, moves with the same velocity and in the same direction; and if the pendulum itself has the same motion, in addition to that by which it vibrates: then the relative positions of the pendulum and the table remain as before. The point of suspension will continue to be over the centre

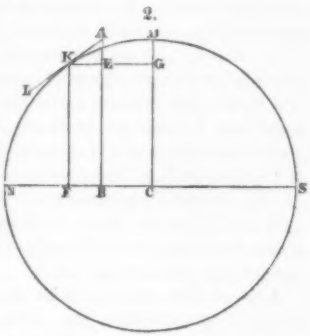
* During the month of June, 1851, while I was preparing to perform the pendulum experiment, at this place, the Rev. J. L. Dagg, President of our University, showed me a mathematical demonstration, by himself, of the principles involved in the experiment. It appears to me exceedingly simple and comprehensive; the annexed copy I have procured from Dr. Dagg, and, with his permission submit it for publication. Your Journal from time to time, has contained several excellent articles on the subject: yet a compact, geometrical demonstration, like the above, may be acceptable to many teachers, who have felt the need of a simple and concise form, in the instruction of classes. Yours truly, J. E. Willet.

Mercer University, Penfield, Geo.

of the table; and the pendulum will continue to vibrate over the same diameter as before.

Let us suppose that the pendulum, its point of suspension, and the centre of the table, are all moving as in the last case, with equal velocity, in the same direction, as towards E; but that the point A of the table, is moving in the same direction, that is towards D, with a greater velocity. In this case, the point A will leave the pendulum which was vibrating from A to L behind it; and the effect on their relative position will be the same as if the diameter over which the pendulum vibrated, receded from the position AL to the position CH. Since the table is a solid, the excess of velocity at A over that of the centre K, will tend to give to the whole mass a rotary motion around the centre. Hence, if another pendulum be supposed to vibrate from the same point of suspension, over any other diameter, as NO, its relative direction will change with the same angular velocity as the former; and the diameter over which it vibrates, will appear to recede from NO to MP.

Let NDS, fig. 2, represent a meridian of the earth. Let the table, fig. 1, be supposed to touch this meridian at K. From the extremity A of its diameter, and from its centre K, let perpendiculars AB and KF be drawn to the earth's axis, NS.



It is manifest that the diurnal motion of the earth carries the point A around the earth's axis, with a greater velocity than the point K, since it describes a greater circle in the complete revolution. The excess of the velocity of A over that of K, will, as has been explained, cause a pendulum, vibrating over the diameter AL of the table to recede from the point A: and a pendulum, vibrating over any other diameter of the table, to change its relative direction, with the same angular velocity.

The velocity of A, is to the velocity of K, as the circumferences of the circles which they respectively describe; and these circumferences are as their radii AB and KF. Hence, velocity of A − velocity of K; velocity of K :: AB − KF = AE : KF. The velocity of K carries the point K in 24 hours, through a circle whose radius is KF. Hence it follows from the last proportion, that the velocity of A − the velocity of K would suffice to carry a point in 24 hours through a circle whose radius is AE. If AE were the radius of the circle in which the pendulum moves in receding from the point A, it would complete a revolution in 24 hours. But, in this motion, the pendulum in fact describes a circle around the point K, the radius of which is AK. Hence, 24 hours : time of revolution :: AE : AK. But the angle AKE is equal to the angle KCG (which is the latitude of the point K) each being the complement of CKG. Hence, AE : AK :: sine of the latitude : radius. We have therefore the following proportion,

Sine of latitude : radius :: 24 hours : time of revolution.

5. *On the distinctions supposed to limit the Vegetable and Animal Kingdoms;* by EDWIN LANKESTER, M.D., F.R.S, (Notices of meetings of the Roy. Ins., Mar. 24, 1854.)—In commencing, the Lecturer made some general remarks on classification, and pointed out the importance of accurate definitions in order to constitute the classes, families, genera, and species of the naturalist. The importance of defining species was greater than that of larger groups, because these were composed of species. As genera were collections of species, and families collections of genera, so the animal and vegetable kingdoms were but collections of species. The difficulty in distinguishing between the animal and vegetable kingdoms consisted in our imperfect knowledge of the characters of species which existed on what might be called the limits of the two kingdoms. The history of the attempts at defining animals and plants, for systematic purposes, would afford the best idea of the nature of these difficulties. The definition of Linnæus, that minerals grow, plants grow and live, animals grow, live, and feel, was first examined. In order to apply this definition, the terms growth, life, and feeling, required explanation. *Growth* simply indicated increase. The term *life* could not be defined in such a manner as to render it inapplicable to the physical phenomena of the inorganic world and at the same time embrace the lowest forms of organized beings. *Feeling* could not be defined so as to separate the movements evinced by so many members of the vegetable kingdom on the application of external stimulants, as the movements of the leaves of the sensitive plant, of the *Dionæa muscipula*, the stamens of the *barberry*, and the closing and unfolding of flowers, from those of the animal kingdom. Such were the distinctions attempted to be made by one who disregarded the use of the microscope.

One of the most obvious distinctions between the organic and inorganic kingdoms was the presence of the cell in the former. Under some circumstances it was not easy to detect the cell, as in certain fossils, and sometimes inorganic matters assumed a cellular form.

Another distinction adopted by naturalists, even since the general introduction of the microscope into natural history inquiries, was, that animals moved, whilst plants were fixed. This distinction, though applicable to the higher forms of plants and animals, was more than ever applicable to the organisms which required the microscope to detect their existence. Recent researches had shewn that the motile tissues in animals were composed of the same substance that was found to be present in the cells of all plants, and which under the names of nucleus, cytoblast, primordial utricle, and endoplast, had been recognised by all vegetable physiologists. This substance, composed of protein, was as actively motile in the plant as the animal. It was this substance which gave motility to the cells of *Protococcus*, the fibres of *Oscillaria*, the spores of various *Conferræ* and *Fungi*, and probably also to all other movements observed amongst plants.

When cilia were originally discovered as the agents of movement in infusoria, and upon the internal organs of higher animals, they were regarded as characteristic of animal life. These organs were now known to be present in the zoospores of various Confervæ, and were the active agents of movement in the *Volvox globator*, of whose vegetable

nature there could be little doubt since the researches of Williamson and Busk.

The possession of what were called eye-spots in doubtful organisms had been brought forward to decide the animality of these beings. Such eye-spots were present as red points in certain stages of the growth of *Volvox*, and other undoubtedly vegetable organisms, and according to Henfrey, were due to the relation of the contents of the cell to light, and were in no way the agents of vision in the cells in which they are found.

The definition of Aristotle, that animals possessed a mouth, whilst plants had none, had been recently revived; and of all merely structural characters, it was the one best suited to the purpose of the naturalist. Until recently the exceptions to this definition were numerous; but since the botanist had claimed so large a number of mouthless infusoria, as the *Diatomaceæ*, *Desmideæ*, and *Volvocineæ*, it was more than ever applicable. There were, however, certain exceptions; and these were found in the *Foraminifera*, the *Difflugiæ*, and other low organisms which had no permanent mouth. Some of these have the power of forming a temporary sac for the purposes of digestion.

Chemistry had from time to time offered its aid to the naturalist. At one time, the possession of *cellulose* by the vegetable kingdom was considered distinctive, and the ready application of iodine and sulphuric acid as the test of its presence rendered it an easily ascertainable diagnostic mark. It had, however, been recently detected by Smid in the Ascidian mollusca, by Thwaites in the Acaridæ, and by Virchow in the brain and spleen of man.

Another substance, *chlorophyll*, appeared at one time, to pronounce the presence of plants; but it had been found by Schulz in *Hydra*, *Turbellaria*, *Vortex*, *Mesostomum*, *Stentor*, *Bursaria* and other decidedly animal organisms.

Starch was another vegetable product, easily detected by iodine, whose universal presence in the plant seemed to offer the best practical chemical test; but Busk and other observers had recently detected this substance in the brain of man, and there was reason to suppose that starch might be very generally present in the animal kingdom.

It was thus seen that no one point in structure or chemical composition could furnish a means of distinction. A physiological point of much interest and importance had principally determined a certain number of botanists in claiming the *Diatomaceæ* and *Desmideæ* as plants. In certain Confervæ it had been observed, that previous to the production of the zoospore, two contiguous cells united, and each contributed its contents to form the germinating spore. This process was observed by Ralf and others in *Desmideæ*, and subsequently by Thwaites in the *Diatomaceæ*. In addition to this point these families exhibit other relations with the vegetable kingdom.

Whatever might be the difficulties presented in any individual case in the application of all or any of the before-mentioned distinctions, there was evidently a great antagonism or polarity exhibited by the animal and vegetable kingdoms when viewed as a whole. They were mutually dependent, attained the same ends in their growth and organization, but by contrary means. The great function of the animal tis-

sues was the absorption of oxygen, and the disengagement of carbonic acid. The great function of the vegetable tissues was the absorption of carbonic acid and the disengagement of oxygen. The processes in the history of the life of the two kingdoms in which these distinctive functions appeared to be reversed, were not exceptions to the law, but were due to other agencies than those connected with the essential life of the plant or the animal. Thus carbonic acid was given out by plants at night, during fructification and germination. In the first instance, the gas given out was that which had been taken up during the day, and was not decomposed by the agency of light. In the latter instances a process of exudation took place in which the contents of the cells were undergoing change independent of the life of the plant. The germ during the growth of its cells absorbed carbonic acid and gave out oxygen, as in the growth of all other vegetable cells. The development of the carbonic acid arose from the decomposition of the starch and the sugar of the albumen of the seed. In the cases where animals had been found to give off oxygen, it was doubtful as to whether plants were not present or even mistaken for animalcules.

The composition of a series of vegetable and animal products was exhibited; and attention was drawn to the fact, that in all cases the vegetable compounds were formed from carbonic acid and water, or from carbonic acid, water, and ammonia, by the loss of oxygen. Acetic acid was referred to as an exceptional instance; but it was shewn that it was more probable, where acetic acid occurred as the result of vegetation, that it occurred as the result of deoxydation than of a process of fermentation in which alcohol was developed and subsequenty oxydised. An exception was also referred to in the animal kingdom in which fat is supposed to be formed by the deoxydation of sugar; but attention was drawn to the fact that this process admitted of another explanation, not opposed to the physiologico-chemical distinction pointed out.

These processes were further shewn to be connected with the relations existing between the animal and vegetable kingdoms. The plant was produced from mineral compounds—carbonic acid, water, and ammonia,—the substances out of which the animal was formed; and no instance was known of the animal appropriating and forming organic substances out of these compounds. This was the distinguishing feature of the life of the plant, and the liberation of oxygen gas its most constant result. The appropriation of substances thus formed, and the uniting them once more to oxygen gas, was the distinguishing feature of animal life, and the formation of carbonic acid gas its most constant result. Minor changes occurred; but these were the grand distinguishing features of the two kingdoms, the recognition of which by structure, function, or results could alone enable us to distinguish between plants and animals.

6. *Letter on the Smithsonian Institution*, by Prof. Agassiz, *addressed to the Hon. Charles W. Upham.—Dear Sir:*—Every scientific man in this country has been watching with intense interest the proceedings of the Smithsonian Institution ever since its foundation, satisfied, as all must be, that upon its prosperity the progress of science in America in a very great measure depends. The controver-

sies which have lately been carried on respecting the management of the institution have increased the solicitude of its friends with regard to its future prospects in a degree which can hardly be realized by those who are not immediately connected with the great cause of science.

As a foreigner, who has enjoyed but for a few years the privilege of adding his small share to support the powerful impulse which scientific investigations have lately received from those who are the native representatives of science in America, I have thus far abstained from taking any part in this discussion, for fear of being charged with meddling with matters in which I have no concern. There is, however, one feature of the institution itself, which may, I trust, justify the step I have taken in addressing you upon this subject as the chairman of the committee elected by the House of Representatives to investigate the proceedings of that establishment.

With the exception of a few indirect allusions, I do not see that any reference is made in the discussion now going on to the indisputable fact that the Smithsonian Institution is *not an American institution*. It was originated by the liberality of a high-minded English gentleman, intrusting his fortune to the United States to found in Washington an institution *to increase and diffuse knowledge among men*. America, in accepting the trust, has obtained the exclusive management of the most important and the most richly endowed scientific institution in the world; but it is at the same time responsible to the scientific world at large for the successful prosecution of the object of the trust, which is to *increase* and *diffuse* knowledge among men.

Were it not for this universal character of the institution, I would not think it becoming in me to offer any suggestion with regard to it. As it is, I feel a double interest in its prosperity—in the first place, as an institution destined to foster the progress of science at large, and without reference to nationalities or local interests, and next, as more immediately connected with the advancement of science in the country of my adoption.

The votaries of science may differ in their views about the best means of advancing science, according to the progress they have themselves made in its prosecution; but there is one standard of appreciation which cannot fail to guide rightly those who would form a candid opinion about it. I mean the lives of those who have most extensively contributed in enlarging the boundaries of knowledge.

There are two individuals who may, without qualification, be considered the most prominent scientific men of the nineteenth century—Cuvier and Humboldt. By what means have they given such powerful impulse to science? How have they succeeded not only in increasing the amount of knowledge of their age, but also in founding new branches of science? It is by their own publications and by aiding in the publications of others; by making large collections of specimens and other scientific apparatus, and not by the accumulation of large libraries. Humboldt never owned a book, *not even a copy of his own works*, as I know from his own lips. "He was too poor," he once said to me, "to secure a copy of them;" and all the works he receives constantly from his scientific friends are distributed by him to needy students.

Again, there is hardly a scientific man living on the continent of Europe, who is not indebted to him for some recommendations in the proper quarter for assistance in the publication of their works. I mention more particularly these details about Humboldt, because he is happily still among the living, and his testimony may be asked in a matter of such deep importance to the real progress of science. But the same is equally true of the part Cuvier took in his day in promoting science. All his efforts were constantly turned towards increasing the collection of the *Jardin des Plantes*, and supporting the publication of original researches, giving himself the example of the most untiring activity in publishing his own.

In this connection, I ought not to omit mentioning a circumstance to which the United States owes the legacy of Smithson, which I happen accidentally to know, and which is much to the point, in reference to the controversy concerning the management of the Smithsonian Institution.

Smithson had already made his will, and left his fortune to the Royal Society of London, when certain scientific papers were offered to that learned body for publication. Notwithstanding his efforts to have them published in their transactions, they were refused; upon which he changed his will and made his bequest to the United States. It would be easy to collect in London more minute information upon this occurrence, and should it appear desirable, I think I could put the committee in the way of learning all the circumstances. Nothing seems to me to indicate more plainly what were the testator's views respecting the best means of promoting science than this fact.

I will not deny the great importance of libraries, and no one has felt more keenly the want of an extensive scientific library than I have since I have been in the United States; but, after all, libraries are only tools of a secondary value to those who are really endowed by nature with the power of making original researches, and thus increasing knowledge among men. And though the absence or deficiency of libraries is nowhere so deeply felt as in America, the application of the funds of the Smithsonian Institution to the formation of a library, *beyond the requirements of the daily progress of science*, would only be, in my humble opinion, a perversion of the real object of the trust, inasmuch as it would tend to secure facilities only to the comparatively small number of American students who may have the time and means to visit Washington when they wish to consult a library. Such an application of the funds would in fact lessen the ability of the Smithsonian Institution to accomplish its great object, (which is declared by its founder to be the increase and diffusion of knowledge among men,) to the full extent to which they may be spent towards increasing unduly the library.

Moreover, American students have a just claim upon their own country for such local facilities as the accumulation of books affords.

If I am allowed, in conclusion, to state my personal impression respecting the management of the Institution thus far, I would only express my concurrence with the plan of active operations adopted by the Regents, which has led to the publication of a series of volumes, equal in scientific value to any production of the same kind issued by learned societies anywhere.

The distribution of the Smithsonian Contributions to Knowledge has already carried the name of the Institution to all parts of the civilized world, and conveyed with them such evidence of the intellectual activity of America as challenges everywhere admiration: a result which could hardly be obtained by applying the resources of the Institution to other purposes.

7. *On the So-called "Fountain of Blood" of Honduras;* by Dr. E. D. North, (from a note to one of the Editors.)—It would seem that my friend, Mr. Ogden Rood, who is now in Germany, neglected to report to the Editors of the Journal the explanation obtained through the microscope of the brownish-red liquid from the "Fuente de Sangre" or Fountain of Blood, noticed in the Number for November last.

The brown liquid according to my examinations and also Mr. Rood's must be *a solution of the dung of Bats!* Nearly a year ago Mr. Rood left with me a few drachms of a reddish liquid, with a request that I should examine it and give him my opinion as to what it was. Being in haste, he gave me no account of the locality from which it was obtained, and indeed seemed to know nothing concerning the article, except that it was from some cavern. When I next saw him, he had himself examined the liquid and without having learned anything more of the locality and history of the sample had come precisely to the same conclusion as I myself had done. The liquid had evidently been copiously diluted, yet a drop confined by a bit of thin glass on a slide exhibited in as large number as could be expected in a substance excessively diluted with water, various of the harder and less destructible or digestible parts of insects, together with *perhaps* occasional fragments of small crustaceans. No memoranda were made and but few examinations, for the reason that the slightest and most cursory search revealed a sufficient number of such objects, and *no other remains whatever.* All that was necessary was to pass the whole of a single diffused drop through the field of view. Perhaps the branched spines of caterpillars which were quite common, in addition to the harder portions of legs, wings, corneæ, &c. indicated the excrement of birds as well as bats, for I do not know whether the latter take insects otherwise than in the air.

Since the notice of the "fountain" mentions that the cavern is frequented by "vast numbers of large bats (vampyres)" that "the liquid has the color, smell and taste of blood" (of course, we may make large allowance for exaggeration) and that "dogs eat it eagerly" we may conclude that the vampyres gorge themselves to that extent that, as is common with all animals overfed, much of their food passes without being digested. As to the statement that the "blood" is found "in a state of coagulation," a physiologist will withhold his belief until a careful examination is made by one who knows what the coagulation of blood really is. Evaporation and settling will reduce a solution of any dung to a semi-solid mass.

A suggestion is made that the character of the liquid may be due to Infusoriæ. Do even the unquestionably animal Infusoriæ ever cause by their death,—no matter how vast their numbers—a putrefactive and offensive fermentation? One of their offices when living being to counteract the effects of putrefaction, is it not a fact that they themselves are so organized or constituted, as not materially to corrupt the liquid in which they die?

8. *On a large Diamond from the district of Bogagem, Brazil;* by M. DUFRÉNOY, (L'Institut, No. 1096.)—M. Halphen has received recently from Brazil a diamond of remarkable dimensions, purity, and crystalline form. It has been called *l'Etoile du Sud*. It weighs 52·375 grammes, or 254½ carats. It will be reduced in cutting to about 127 carats. It is therefore among the four or five finest diamonds known. The Regent weighs 136 carats; the Kohinoor 120 to 122 carats; the Duke of Tuscany 139, the Great Mogul 279 carats, the Orlow, 195. It is perfectly limpid, and has the peculiar lustre which gives the diamond its highest value. The commercial value of the *Star of the South* has not been estimated. The Regent is estimated at six millions of francs. The form is a rhombic dodecahedron, having the edges bevelled and thus passing to a solid of 24 faces. The surface is unpolished and slightly chagrined, and shows some striæ corresponding to the octahedal cleavage. Its specific gravity is 3·529 at a temperature of 15 C.

On one of the faces there is a cavity, evidently due to an octahedral crystal implanted in it, as shown by its form and the octahedral striæ which it has copied. On another face there are two other cavities which were similarly formed by octahedral crystals. Moreover there is on this side a cleavage fracture, which I am disposed to believe was the point of attachment of this diamond to the gangue, from which it was apparently detached by alluvial causes. I also distinguish some black lamellæ which appear to be titaniferous iron, a mineral frequently found associated with quartz crystals in the Alps and Brazil.

It results from these facts that the *Star of the South* was originally one of a *group of diamond crystals*, analogous to a group of crystals of quartz and other minerals. The diamond therefore occurs in geodes in certain rocks as yet unknown, but which according to the observations of M. Lomonosoff belongs among the metamorphic rocks of Brazil.

The *Star of the South* was found near the close of July 1853, by a negress employed at the mines of Bogagem one of the districts of Minas-Geraes. It is the largest diamond yet brought from Brazil. This diamond will be exhibited at the Paris Exhibition of 1855.

9. *Observations of the Variable Star Algol wanted*, (from a letter addressed to the Editors, by B. A. GOULD, dated Cambridge, 1855, Feb. 9.)—*My Dear Sirs*:—Professor Argelander has sent me a communication upon the variability of *Algol*, together with an ephemeris of the minima visible in America during the current year, and so full instructions concerning the proper method of observation, that it is within the power of any one, who can be sure of his time to within one minute and who will devote some little care to the process, to furnish by means of his unassisted eye, exceedingly valuable observations. The Astronomical Journal comes into the hands of comparatively few, and professional astronomers furnished with valuable instruments feel it their duty to give themselves to such observations as cannot be made by those destitute of these facilities; and I venture therefore to indulge the belief that many lovers of science may through your Journal be induced to devote themselves to the labor of attaining additional facts for the study of this singular and interesting phenomenon. You will therefore pardon me for asking your aid in calling the attention of your

large circle of readers to the subject and requesting all who are interested in the progress of astronomy and can spend the time for observation, to do their part in contributing to the materials available for investigating this variability—which is one of the most remarkable of all the unexplained phenomena of Sidereal Astronomy.

Note.—Dr. Gould desires us to state that he will send to any observer who may request it, a copy of the No. of the Astronomical Journal, (1855, Jan. 31,) which contains Prof. Argelander's communication. We propose to copy it in our May Number.—Eds.

10. *Discovery of Gold in Australia.*—The first discovery of Australian gold belongs to the Rev. W. B. Clarke, who has long been engaged in Geological researches in New South Wales. The following letters addresed to Mr. Clarke are part of the evidence taken before a government committee on this question.

From R. Therry, Esq., one of Her Majesty's Judges of the Supreme Court, dated Keera Vale, Wollongong, October 2, 1852—*My Dear Sir*,—"I can have no hesitation in stating, I quite well recollect the circumstance of your communicating to me your discovery of gold. The conversation took place on board the Paramatta steamer some time in 1844 on my return to Sydney from a visit to a part of the country which I then represented in the Legislative Council. On that occasion you showed a piece of quartz in which two or three large specks of gold shone very distinctly and brilliantly; and you intimated that from that and other specimens you had seen, and from the geological observations you had made, you were confident that gold would be found in abundance in this colony. I mentioned the matter to many of my friends at the time, and the recent extensive discoveries of gold brought very vividly to my recollection your predictions which these discoveries have verified.

I therefore, can have no objection to the mention of my name in the manner in which you have introduced it in your evidence."

From James Macarthur, Esq., M.L.C., who was Chairman of the Gold Committee on 24th September, 1852, *dated Camden Park, Camden, 29th July*, 1854.—*My Dear Sir*,—"I have deferred answering your note in order to refresh my memory by a reference to memoranda connected with public transactions, which I know took place at the period of our conversation, relative to your *first* discovery of gold in the Hartley District, and your conviction, from geological investigations, that Australia would prove to be a great *gold*-producing country. I find, upon reference to those memoranda, that your communications to me, on the above subjects, must have been in 1843 and the early part of 1844. I well recollect that you pointedly alluded to the grave objection to opening gold mines to the cupidity of a population which at that time constituted the great majority of the inhabitants of these colonies, and you mentioned the strong views entertained by Sir George Gipps as to the ill consequences to be dreaded from a disclosure of what you had ascertained." * * * *

11. *Stereoscopes.*—The great beauty and perfection of photographic views in a stereoscope have given great and deserved popularity to this new instrument. We have recently received a form of it from J. F. Mascher of Philadelphia (No. 408 North 2nd st.), which is exceedingly

convenient, and effective. It is hardly larger than a common daguerreotype case and has all its compactness and simplicity, and requires but a single trial to be fully understood and appreciated. The views accompanying it are excellent, and those on glass especially are wonderfully life-like. A view of the Suspension Bridge at Niagara for example, has in effect all the length and depth and sublimity of the natural scene. Another of Mount Vernon transports you instantly to the place, and the trees seem to stand around you and almost overhang your head—the only deficiency is that the leaves are motionless. Views of statuary, as is well known, present most admirably the effect of the real statue. There is no reason why the complete galleries of Florence, Rome and other cities should not be on exhibition in this and other countries. Mr. Mascher makes these instruments of a great variety of forms, besides the simple one here alluded to.

12. *Heights of Perpetual Snow in the Alps.*—M. Roret has deduced from observations during the years 1851, 1853 and 1854 in the French Alps that the height of perpetual snow is 3400 meters, or 700 meters above the height stated in many works on physics and meteorology.—*L'Institut*, No 1093.

13. *Hail at Cuba.*—Hail is of very rare occurrence in Cuba, and the neighboring islands. According to M. Poey no hail fell at Havana from 1784 to 1825, an interval of 40 years. Between 1825 and 1828 there were two years without hail. There were also 17 years from 1828 to 1846 without hail; but from 1846 to 1849, there were four cases of hail, three of which occurred in the same year, 1849, one in March, two in August. There was none in 1850.—*L'Institut*, No. 1092.

14. *Gold near Reading, Pa.*—Dr. C. M. Wetherill has confirmed his former announcement of the discovery of gold near Reading. The gold was discovered by Mr. Philipps, a mining geologist, searching for iron ore, a few miles westward from Reading and on the farm of Mr. Entlich, also on the western slope of Penn's Mount. It was obtained in washing specimens of ferruginous quartz.

15. *On the Mountain Systems of America.*—M. J. Marcou presented a paper on this subject to the Academy of Sciences, Paris, Dec. 26, 1854.—*L'Institut*, No 1096.

16. Obituary.—*Professor Edward Forbes*, (Ath., Nov. 25, 1854.)—Professor Edward Forbes was born at Douglas, in the Isle of Man, and received there his early education. When very young he acquired a taste for natural history; but, evincing talent for drawing, he was induced to commence his studies as an artist, and, with this object in view, he attended for six months the studio of the late Mr. Sasse in London. In after life, in his travels and natural history studies, he felt the advantage of this short training. His love, however, of natural history led him to the medical profession, as affording him a wider field for his favorite pursuit. He accordingly repaired to Edinburgh, where he commenced his career as a medical student in 1830. Although he pursued his medical studies with great zeal and success, he never presented himself for his degree at the University. He had, in fact, contracted so strong an attachment for the sciences of zoology and botany,

that he determined to devote himself to a scientific career. Whilst a student, plants and animals seemed equally to attract his attention. It was, however, in a knowledge of the lower forms of the latter,—the Mollusca and Radiata,—that he was most distinguished. Whilst still a student at Edinburgh, he had an opportunity of making a voyage in the Mediterranean, and visiting the coast of Algiers, and one of his earliest published papers was 'On the Land and Fresh-water Mollusca of Algiers and Bougia.' About this time he also visited the continent of Europe, resided for some time in Paris, and made a tour in Norway. During this time he was active in the pursuit of natural history, and he published several papers giving the result of his observations. Among these may be mentioned, 'Notes of a Natural History Tour in Norway', 'On the Comparative Elevation of Testacea in the Alps,' and 'Malacologia Monense: a Catalogue of the Mollusca inhabiting the Isle of Man and the neighboring Sea.'

Whilst a student in Edinburgh he acquired a remarkable ascendancy over the minds of his fellow students,—and many of his contemporaries, who have since pursued a successful career of natural history study, have traced it to his influence. This power of drawing men under his influence increased with his years; and, perhaps, few men of his age have produced so permanent an effect on the minds with which he came in contact. It was in Edinburgh that he may be said to have invented the art of dredging, for till his time it had scarcely been regarded as a part of the serious work of the naturalist. He drew attention to the important results that could be obtained by the use of this simple instrument, which had been only employed by fishermen to procure shell-fish. His numerous papers at this time 'On the Structure and Forms of the Marine Invertebrata' attested the value of the dredge, and with it he may be said to have opened a new field of research, if not a new branch of science. It was, afterwards, with this instrument, in the Ægean Sea, that he made the important observations by which he was enabled to point out the great law, that as there were zones of animal and vegetable life in altitude on the sides of the mountains that covered the earth, so there were zones of animal and vegetable life in depth on the sides of the valleys of the ocean.

Frequent records of his dredging excursions are to be found in the pages of the *Magazine of Zoology and Botany;* and through his influence Dredging Committees have been appointed by the British Association,—whose labors have greatly contributed to enlarge our knowledge of the inhabitants of the British seas. One of the earliest and most important of his systematic works was the result of his dredging labors. This was his 'History of British Star-fishes and other Animals of the Class Echinodermata,' published in 1841. In this work he displayed a minute and comprehensive knowledge of the class of animals to which it was devoted,—and added not only many species new to the British Fauna, but many species were here described for the first time. Though on a subject far removed from ordinary human sympathy, he gave it a wide interest by lively descriptions, pretty vignettes and quaint tail-pieces, all from his own pencil.

When, subsequently, he became a geologist, and one taking rank with the most distinguished, it was his practical acquaintance with the

bed of the ocean, which he had acquired by means of the dredge, that gave his opinions weight, and which enabled him to determine points in the age and relationship of the strata of the earth that had hitherto been unsolved problems.

In 1841 Mr. Forbes obtained the appointment of Naturalist to H. M. Surveying Ship Beacon, which was commissioned to bring from Lycia the marbles brought to light by Sir Charles Fellows. In the spring of 1842 he was occupied with the Rev. Mr. Daniell and Lieut. Spratt in examining the coast and country of Lycia. In this journey Mr. Daniell fell a victim to the fever of the country, and Mr. Forbes had an attack, the effects of which he occasionally felt till within a short period of his decease. An account of their joint labors,—which resulted in the discovery of the sites of eighteen ancient cities,—was afterwards published by Messrs. Spratt and Forbes in their 'Travels in Lycia.' It was during this voyage that Mr. Forbes prosecuted his researches with the dredge in the Ægean, which resulted in the enunciation of the law for the development of animal and vegetable life in the depths of the ocean. The results of these researches were first made known in a 'Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology,' made to the British Association, at their meeting at Cork, in 1843.

During his absence on this voyage, the chair of Botany at King's College, London, became vacant by the death of the late Mr. David Don. Although his later published papers had been on zoology, Mr. Forbes had devoted much attention to botany, and was known for applying the same acumen to the study of plants and their distribution as he had now become so distinguished for in relation to the lower forms of animals. He was the successful candidate for this chair, which he filled with great success till his recent appointment to the chair of Natural History at Edinburgh. Those who attended his class will ever remember the charm he threw around the study of Vegetable Structure and the delightful hours they spent in his company during the periodical excursions, which he made a point of taking with his pupils, in the neighborhood of London. Nor were these excursions attended by pupils alone. Many are the distinguished men of science in London who sought this opportunity of availing themselves of his great practical knowledge of every department of natural history. It was during the delivery of his first course of lectures 'On Botany' that he worked out the interesting relations that exist between the morphology of the reproductive system of the Sertularian Zoophytes and its analogy with that of flowering plants. His paper on this subject was read at the British Association, at York, in 1844.

He now also obtained the appointment of Librarian and Curator to the Geological Society. He occupied this position till his appointment to the Palæontological Department of the Museum of Economic Geology in 1846.

Although the chief part of his time was now occupied in the practical details of palæontology, he still found leisure to arrange some of the vast mass of original matter which he had collected during his dredging excursions. In 1848 he wrote for the Ray Society a 'Monograph on the British Naked-eye Medusæ.' This work was beautifully

illustrated from drawings made by himself. It was characterized by the same extensive research and accuracy of detail that distinguished his 'History of Starfishes,'—and is one of the most important contributions ever made to this department of natural-history literature. No sooner was this work published than we find him engaging, in conjunction with Mr. Henley, in the publication of a 'History of British Mollusca.' This work was completed, in four volumes, in 1853.

It was not long after his connection with the Geological Society and Museum of Practical Geology, that the fruits of his closer acquaintance with the facts of geology became apparent. One of the most remarkable contributions to the science of geology in this country appeared in the first volume of the 'Memoirs of the Geological Survey of Great Britain.' This paper, which may be regarded as a work on the subject, is entitled 'On the Connection between the Distribution of the existing Fauna and Flora of the British Isles, and the Geological Changes which have affected their area.' In this work the happy combination of great botanical and zoological knowledge is made to bear on some of the most intricate inquiries with regard to the age and relationship of the rocks of Great Britain. From this time the Transaction of the Geological Survey, and the 'Journal of the Geological Society,' were enriched with his papers, all displaying accurate and extensive observation, combined with profound and original thought. Turning to the list of his papers and works on Zoology and Geology, in the 'Bibliography,' published by the Ray Society, we find them amounting to eighty-nine. This list does not comprise his 'Botanical Papers,' or those published since 1850, which together are very numerous. But whilst thus engaged in severe scientific toil, he found time to engage in lighter literary occupations,—contributing to more than one periodical. We will not speak of his contributions to the *Athenæum*, though they were many and valuable. His article on 'Shellfishes, their Ways and Works,' in the first number of the new series of the *Westminster Review*, is a gem in its way; and the brilliant article on 'Siluria,' in the last number of the *Quarterly*, was from his pen. At the time of his death he was engaged on several works. The one which he early announced, under the title of 'Rambles of a Naturalist,' he still intended to complete. Another, the 'Zoology of the European Seas,' is nearly all printed. He was also preparing for publication the results of his researches in the Ægean.

Young as he was, such a man had earned the highest honors that natural history science could confer, and to the honor of those with whom he associated, they were not slow to discern and reward his merits. In 1852, he was elected President of the Geological Society, and sat in the chair which had been filled by Prof. Sedgwick, Sir Roderick I. Murchison and Sir Charles Lyell, who bore willing testimony to the genius of their youthful successor. In 1854, he was appointed President of the Geological Section of the British Association. He was early elected a Fellow of the Royal Society, and appointed a member of its Council.

When the illness of Prof. Jameson rendered it necessary that a successor should be appointed, all interested in the prosperity of the University of Edinburgh looked to Prof. Forbes as his successor. He ob-

tained this appointment in 1853. He was enthusiastically welcomed by professors and students to his *Alma Mater*. He was proud of having attained the position which, as a student, he had hoped one day to fill. He lived to complete but one course of his lectures. But though he is gone, his spirit survives in his works, and these will ever form an important part of the history of natural science during the present century.

He was buried on Thursday last: the town council and professors of the University and students following his remains to the grave.

17. *Faraday's Lectures*, (The subject matter of six lectures on the Non-metallic Elements, delivered before the members of the Royal Institution in the spring and summer of 1852.) 12mo. pp. 293. *London*, Longmans, 1853.—This interesting little volume has apparently escaped general attention in this country, not having been republished. Like everything emanating from the same source it is marked by originality, clearness and the broad philosophical spirit in which the several topics, apparently so trite,—are handled. It abounds in every lecture with highly suggestive remarks on the general tendencies of chemical philosophy and especially as this science receives new light from the late recent advance of our ideas respecting the subject of Allotropism. The topics are treated in the following order: Lecture 1st, Oxygen (and ozone); 2nd, Chlorine, Bromine and Iodine; 3d, Hydrogen; 4th, Nitrogen (including ammonia and respiration); 5th, Sulphur and Phosphorus; 6th, Carbon. Each lecture is preceded by an introduction rehearsing the well established elementary facts bearing on the subject of the lecture; and in a general introduction, the history of the science is reviewed in a graphic manner with reference to tracing the golden thread of system and philosophy from its origin to the present time. Every teacher will read these lectures by Prof. Faraday with a high relish sharpened by curiosity to see how the first of living chemical philosophers in England, will handle the plainest topics of elementary chemistry, without becoming either tedious or trite. The various facts relating to the history of Ozone are very fully discussed, and Faraday gives full acceptance to the facts and observations of Schönbein on this subject. Such an unqualified admission of these facts accompanied by interesting generalizations founded on them from so high an authority, must serve to strengthen the faith of doubtful disciples. The proof-reader has been sadly negligent of his task in the editing of this volume otherwise so creditable to Mr. J. Scoffern, M.B., late Professor of Chemistry at Aldersgate College, who was permitted the use of the author's notes in preparing these lectures for the press. Most of the errors alluded to are such as the reader at once detects, as *property* for *propriety* (p. 49), *an acid*, for *acids* (p. 93), *marked* for *masked* (p. 85), *found* for *burned* (p. 233), &c. But the use of *sulphur* for *sodium* (p. 149, last line), 100 for 80 (p. 84), and similar errors of fact may embarrass the young chemical reader. In that fine experiment illustrating the production of ammonia by the action of spongy platina, on a mixture of *five* vols. of hydrogen with two of binoxyd of nitrogen, the reader is told to mix *one* volume of hydrogen with two of nitrogen (p. 214). Dr. Hare is, if we remember correctly, entitled to the credit of

devising this most satisfactory of all modes of showing the production of ammonia from purely inorganic materials, a fact which Prof. Brande in his lectures on Organic Chemistry applied to the Arts, takes care to mention. An error on page 292 respecting the number of gases that have been solidified, which is corrected in the errata, occurs again on page 79, where we are told that "one gas (carbonic acid) has been condensed—into a solid." Such an editorial error is particularly unfortunate in reporting the lectures of a philosopher who has himself reduced *nine* of the gases to the solid state. Abating these and similar blemishes, we have perused this little volume with the highest satisfaction.

18 *Professor Brande's Ten Lectures* on some of the Arts connected with ORGANIC CHEMISTRY, were delivered also before the Royal Institution, subsequent to those by Prof. Faraday, just noticed, and are reported also by Mr. Scoffern. The subjects discussed are, Lecture 1st, Dyeing, —preceded by an Introduction on the History of textile materials to which dye-stuffs are Applied—2d, On the Operations involved in Bleaching —3d, On Calico Printing—4th, on Gelatine, Tannic and Gallic acids and their applications,—5th, On Sugar and its manufacture with an Introduction on the general and natural history of Sugar—6th, on Woody fibre —7th, on the Chemistry of fatty bodies involving the manufacture of Soaps and Candles: with an Appendix on the collateral influences of the Discoveries of M. Chevreul—8th, On hydrocarbons—9th, on Nitrogenous or Azotized Substances—10th, On the phenomena and products of Fermentation. A glance at these topics will satisfy the reader that the ten Lectures here reported must have possessed uncommon interest coming from a source so abundantly experienced in the Chemical Arts as Prof. Brande. The reports are however so much condensed as to present few new facts to the scientific reader, but notwithstanding this unavoidable defect in a popular performance, the labor of Mr. Scoffern in giving us so good a report of Prof. Brande's lectures will be warmly appreciated.

19. *Outlines of Chemical Analysis, prepared for the Chemical Laboratory at Giessen;* by HEINRICH WILL, Professor of Experimental Chemistry in the University at Giessen. (Translated from the third German edition by Daniel Breed, M.D., and Lewis H. Steiner, M.A., M.D.) Boston and Cambridge: James Munroe & Co., 1853. pp. 279, 8vo.—Dr. Will's "Outlines" is a book too well known to all Chemical teachers and students to require more than the simple announcement of a new translation by Drs. Breed and Steiner from the third (last) German edition. Those who remember only the first edition will find little in the general appearance of the present portly volume to remind them of the thin 12mo of former years. Chemical science has made great progress in the last ten years, and Dr. Will has not been slow in keeping his book up to the times. This work fills an important place among chemical text-books, being much more useful to the young student than the voluminous treatise of Rose, while it is sufficienly full to meet most of the wants of the more advanced student. We have not had an opportunity of proving the accuracy of the present edition from actual use, but it has every guarantee for this important quality.

20. *The Native Races of the Russian Empire;* by R. G. LATHAM, M.D., F.R.S., &c., with a large colored map and other illustrations.

London and New York: H. Baillière, 1854. 12mo, pp. 340.—This is a most timely contribution to the small amount of real knowledge possessed by even intelligent foreigners of the many various races which make up the population of Russia. The great interest universally felt at this moment in everything relating to the vast empire of Russia, will render this descriptive account of the tribes occupying its surface, and including all those nations who have been conquered by the ruling race or absorbed into its body—particularly acceptable. The volume is accompanied by a reduced copy of the great Ethnological and Statistical Map of Russia which was published in 1852 by the Imperial Geographical Society of St. Petersburg.

The author recognises three chief constituent stocks in the Russian Empire, viz., the Ugrian, the Turk and the Sarmatian. These original races are now subdivided into no less than thirty-eight tribes each distinguished on the map by a separate color.

Dr. Latham is beyond doubt the leading authority in our language on all ethnological topics, and his present compendious little volume will be caught up with avidity by thousands who would have hesitated to grapple with a more extended work, while the amount of new facts and new summaries of old facts is such as to reward the perusal of all.

F. Engel: Axonometrical Projections of the most important geometrical surfaces and drawings for descriptive geometry, with IX plates and a catalogue of models for the study of Optics and the higher branches of Geometry. Price $3.50. [The models in wood or plaster can be had at 343 Broadway, the Depot of J. B. Luhme & Co., of Berlin.]

British Association: Proceedings for 1853. *London*, 1854.

S. S. Garrigues: Chemical Investigations on Radix Ginseng Americana, Oleum Chenopodii Anthelmintici, and Oleum Menthæ viridis. Inaugural Dissertation. 24 pp. 8vo. *Göttingen*, 1854.

Proceedings of the Acad. Nat. Sci. Philadelphia, Vol. VII, No. 6.—p. 196, Characteristics of some of the Cartilaginous fishes of the Pacific Coast of North America; *C. Girard.*—p. 197, Abstract of a Report to Lieut. Jas. M. Gilliss, U. S. N., on the Fishes collected during the U. S. N. Astronomical Expedition to Chili, *C. Girard.*—p. 199, Fossil bones from the banks of the Ohio, Indiana; *J. Leidy.*—p. 203, Loxia leucoptera abundant near Philadelphia; *J. Cassin.*—p. 204, Abstract of Experiments on the Physical Influences exerted by living Organic and Inorganic membranes upon Chemical Substances passing through them by Endosmosis; *J. Jones.*—p. 209, On the question of the identity of Bootherium cavifrons with Ovibos moschatus; *J. Leidy.*—p. 211, Descriptions of the Species of Trox and Omorgus inhabiting the United States; *J. L. LeConte.*—p. 216, Some corrections in the Nomenclature of Coleoptera found in the United States; *J. L. LeConte.*—p. 220, Descriptions of new Coleoptera, collected by T. H. Webb, M.D., in the years 1850, '51, '52, while Secretary to the U. S. Mexican Boundary Commission; *J. L. LeConte.*—p. 226, Abstract of a Report to Lieut. J. M. Gilliss, U. S. N., on the Reptiles, collected during the U. S. N. Astronomical Expedition to Chili; *C. Girard.*—p. 227, A List of Pigeons of the Genus Carpophaga, in the Academy of Nat. Sci. Philadelphia, and of the U. S. Exp. Exped. (Vincennes and Peacock,) Washington; *J. Cassin.*—p. 232, Herrerite identical with Smithsonite; *F. A. Genth.*—Chemical Notices; *C. M. Wetherill.*—p. 236, Rectification of Mr. T. A. Conrad's Synopsis of the Family of Naiades of North America, published in the Proc. Acad. Nat. Sci. Philad. for Feb. 1853; *I. Lea.*

Proceedings of Acad. Nat. Sci., San Francisco.—p. 7, New Fishes of the Genus Sebastes; Centrarchus; Morrhua, Grystes lineatus, Clypeocottus robustus = Aspicottus bison of Girard; Brosmius marginatus *A.*; Syngnathus griseo-lineatus *A.*; Accipenser acutirostris *A.*, A. brachyrhynchus *A.*; Osmerus elongatus *A.*, Mustelus felis *A.*, Catostomus occidentalis *A.*, Gila grandis *A.*,—all by *W. O. Ayres*, pages 7 to 13 all that we have received of the Proceedings.—p. 14, Description of Lavatera assurgentiflora (n. sp.); *Dr. Kellogg.*